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Sky and TELESCOPE

Star trails over Texas

In This Issue:

Vol. XVI, No. 5

MARCH, 1957

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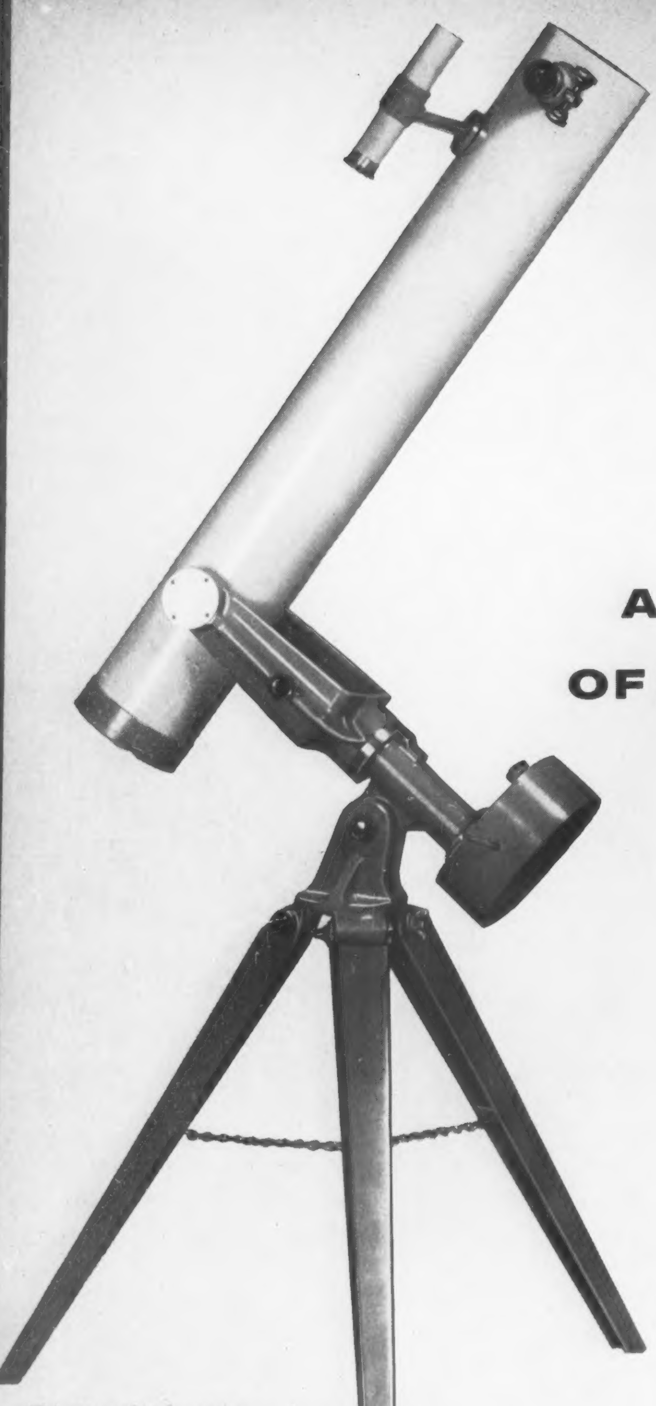

SKY AND TELESCOPE

CHARLES A. FEDERER, JR., *Editor*
JOSEPH ASHBROOK, *Technical Editor*

Vol. XVI, No. 5 MARCH, 1957

CONTENTS

COVER: A time-exposure photograph of the stars around the north pole of the sky, taken by W. S. Warren, at Austin, Texas. During the nearly five hours that the shutter of his stationary camera remained open, the rotation of the earth caused the stars to describe this pattern of circular arcs. (See the story on this page.)

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An All-Star Program

THE STRIKING photograph of circumpolar star trails on this month's front cover was taken by an Austin, Texas, amateur, W. S. Warren. Besides the stars, two television aerials appear in the picture, leading him to comment:

"An age-old spectacle, unsurpassed by anything television can present, is shown in this time exposure of the northern sky. Overpowering the two television antennas in its immensity and grandeur, this particular celestial display only hints at the scenes which pass over the world's citizens every night—many of whom are seated in a darkened room watching a flickering image on a two-foot screen.

"Here the camera records what happens while one watches the northern heavens for some five hours any clear evening at 30° north latitude. Polaris is the bright short arc just to the right of center. The very prominent star trail at the left is that of Kochab, in the bowl of the Little Dipper.

"Late in September, 1953, a 4-by-5 Crown Graphic camera, equipped with a 127-mm. Ektar lens set for f/4.7 and focused at infinity, was placed on a tripod and the exposure begun at about 9 p.m. Almost five hours later the shutter was closed. The film, Super-XX, was processed commercially. Note the dimming of the star trails near the horizon, due to atmospheric extinction."

Peter A. Leavens, Freeport, New York, gives some hints for capturing star trails on film:

"Winter nights provide the best opportunities for star-trail photographs of long duration, but exposures for five or six hours are possible even during the summer. Do not start until the last glow of twilight has disappeared, and the shutter must be closed before dawn begins, if you wish a minimum of sky fog. Tables of moonrise and moonset will have to be consulted to make sure that no lunar illumination interferes.

"Use a fast film and open the lens diaphragm to its fullest, and as the earth rotates you will record hundreds of star paths. If the camera is directed toward Polaris, the trails will be arcs of compact circles, since the earth's axis points to that part of the sky. When the field of the camera takes in constellations like Orion near the celestial equator, the trails become almost straight parallel lines. On occasion, a brilliant meteor may flash across the field of view, leaving its mark across the star tracks."

CORRECTION

In the February, 1957, issue, the diagram at the upper left of page 171 was incorrectly relettered in our editorial office. The labels reading "200 Miles" and "800 Miles" should be interchanged.

One of the nearest of the planetary nebulae is NGC 7293, in Aquarius, its apparent size being 12 by 15 minutes of arc. At its distance of about 600 light-years, this corresponds to linear dimensions of 2 by 2½ light-years. The filamentary structure of the shell is revealed in this 200-inch photograph in red light by Walter Baade. Mount Wilson and Palomar Observatories photograph.

Planetary Nebulae—I

OTTO STRUVE, *Leuschner Observatory, University of California*

WHEN observed visually through a small telescope, a planetary nebula such as the Owl in Ursa Major appears as a small green disk, looking somewhat like the planet Uranus or Neptune. From this resemblance comes the name *planetary*. These two planets owe their pale greenish color to abundant methane gas in their atmospheres, which strongly absorbs yellow and red light, whereas the planetary nebulae are green because of intense emission lines in their spectra, due to the fluorescence of doubly ionized oxygen. These radiations, usually designated N_1 and N_2, have wave lengths of 4959 and 5007 angstroms and appear green to the eye. They are *forbidden* lines, which can be emitted only by gas of extremely low density.

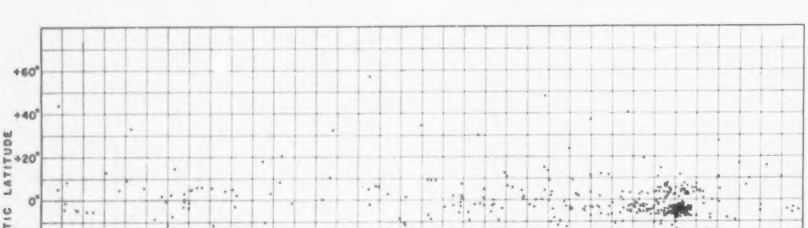
On photographs made with large telescopes, the planetaries show much variety in structure. The largest, NGC 7293 in Aquarius, is a luminous ring appearing about half as large as the moon. W. Baade's photograph of this nebula, reproduced here, shows a vast amount of detail; in the dark inner portion of this object, narrow jetlike streamers suggest violent motions. Some other planetaries are so small that they appear almost starlike. Although this is partly caused by differences in their distances, the true dimensions of the planetaries range from about 20,000 to almost 200,000 astronomical units.

The number of recognized planetaries in our Milky Way galaxy is relatively small. Until about a decade ago only some 100 were known. Since then, R. Minkowski has added several hundred in the central bulge of our galaxy, mostly at great distances; and K. G. Henize has

This large planetary, M97, the Owl nebula in Ursa Major, is well-known to amateurs. It is about 200 seconds of arc in diameter, and about 7,000 light-years away. Lick Observatory photograph.

found more than 100 in the southern sky. We now know some 500 planetary nebulae, at distances up to about 10,000 parsecs from the sun, and there must be hundreds more within this distance that are obscured by interstellar dust clouds. The total number of planetaries in the entire Milky Way may be of the order of 10,000.

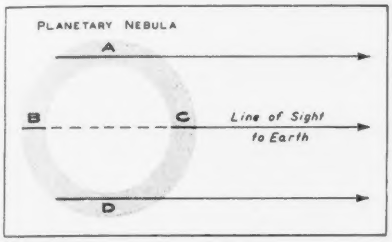
The distribution of the planetary nebulae over the sky shows a marked concentration in the direction of the galactic central bulge, but there are a few at distances of more than 10,000 parsecs from the galactic center. The planetaries are not strongly crowded toward the central line of the Milky Way. Their arrangement in space is a slightly flattened system, resembling that of the RR Lyrae variable stars, and differing from the very flat system of the *O* and *B* stars and of the diffuse nebulae, both bright and dark.



The distribution of 371 planetary nebulae, by R. Minkowski. Reproduced from the "Publications" of the University of Michigan Observatory.

Planetary nebulae, therefore, seem to belong to Baade's Population II, which includes the very old stars of our galaxy (like those in globular clusters), the RR Lyrae variables, and the high-velocity stars. Indeed, one planetary nebula is known to belong to a globular cluster, NGC 7078.

Hence it appears that at least some of the oldest stars, as they evolve, may develop the characteristics of planetary nebulae. Since only one such object is known amid some 10 million stars in globular clusters, we may infer either that the planetary nebula stage is of relatively short duration or that many stars by-pass this stage altogether.



An observer's line of sight passes through much more of the nebular shell at A or D than it does through B and C combined; therefore the shell seems brighter at A and D and the planetary looks like a ring in the sky.

Inside a typical planetary is a very hot central star, whose surface temperature may be of the order of 50,000° to 100,000° K., and which is much smaller than the sun, but with about the same mass. The absolute photographic magnitude of such a star is about 0 or +1.

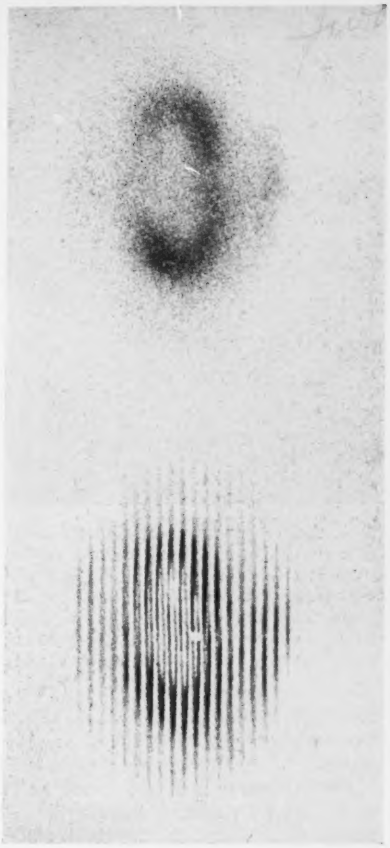
A planetary nebula itself appears much brighter than its central star. Although all of the light of the planetary is derived by fluorescence from the central star, the latter is so hot that it radiates mostly ultraviolet light, and thus appears relatively faint to the eye or photographic plate. The density of a planetary nebula is low—in fact, there are only 10^4 atoms per cubic centimeter—and its temperature as indicated by the random motions of the free electrons is about 10,000°.

All planetary nebulae are expanding, with velocities of about 10 to 50 kilometers per second. This is best seen on the spectrograms obtained by O. C. Wilson with a high-dispersion spectrograph that had many parallel slits instead of the customary single slit. Compare the photograph of NGC 7662 with its multislit appearance; both pictures show only the light of doubly ionized neon at a wave length of 3868 angstroms. Near the center of the nebula the lines are split into two components, which are caused by relative radial velocity shifts, one to the violet and the other to the red. This shows that the nearer side of the planetary is approaching us (violet shift) while the more distant side is receding. Such observations have given some indication that the intrinsically larger planetaries expand at a slower rate than smaller ones.

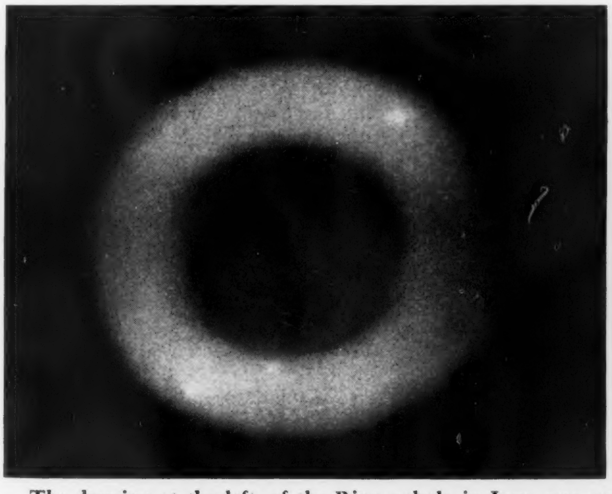
Two recent books,* one by the Soviet astronomer G. A. Gurzadian, the other by L. H. Aller, University of Michigan Observatory, contain a wealth of new information on planetary nebulae. The first book treats their structural features, while the second deals particularly with atomic processes that produce the complicated nebular spectra. Yet, the reader of either book will be struck by how much is still to be learned.

Gurzadian starts with a study of the stability of the planetary nebulae. Many of these objects show a ringlike form; the most famous is NGC 6720—the Ring nebula in Lyra. It was shown by H. D. Curtis many years ago that this appearance can only be explained by assuming most of the nebulous matter to form a relatively thin shell surrounding the central star. As the diagram shows, such a

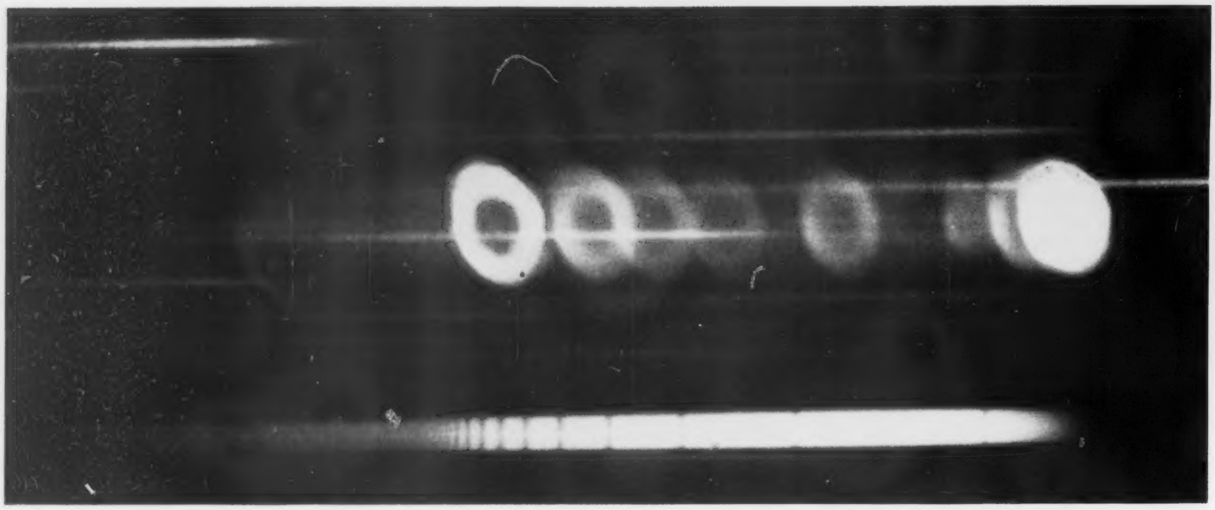
*G. A. Gurzadian, *Dynamical Problems of the Planetary Nebulae*, 1954, Erivan (in Russian). L. H. Aller, *Gaseous Nebulae*, 1956, John Wiley and Sons, Inc.



A negative print of neon images of NGC 7662, made by O. C. Wilson in October, 1952, with the 100-inch reflector of Mount Wilson Observatory.



The drawing at the left, of the Ring nebula in Lyra, was made by the famous astronomical artist L. E. Trouvelot in 1874. He gives an accurate impression of this planetary's appearance in the Harvard Observatory 15-inch refractor. The one-hour photograph at the right was made with the 100-inch Mount Wilson Observatory reflector on August 5, 1921. The central star is about 15th magnitude photographically and very blue; thus it is conspicuous on the photograph but Trouvelot did not see it.



A slitless quartz spectrograph attached to the Crossley 36-inch reflector at Lick Observatory was used to obtain this spectrum of the Ring nebula in Lyra, showing the different sizes of this planetary in various wave lengths. From right to left (red to violet), the eight principal images are at wave lengths 5007 and 4959 angstroms blended (O III), 4861 (hydrogen beta), 4686 (He II), 4340 (hydrogen gamma), 4102 (hydrogen delta), 3969 (Ne III + hydrogen epsilon), 3868 (Ne III), and 3727 (O II). The Balmer continuum extends to the left of the 3727 image. Narrow horizontal streaks in the field are spectra of neighboring stars. The spectrum of the central star is faintly visible, and the comparison star at the bottom is Gamma Lyrae, of spectral class A0. Courtesy L. H. Aller, University of Michigan Observatory.

shell of luminous gas would appear as a disk with a bright periphery and darker center.

The expanding shell of gas that constitutes a typical planetary nebula was presumably once part of the central star. Gurzadian suggests that the actual outflow of gas from the star was of short duration—how short he does not say—and is no longer going on. The ejection of the shell took place within a brief interval, perhaps as long ago as a few thousand years.

(This reminds us of a nova outburst, in which a star blows off its outermost layers. But a planetary nebula contains about 1/10 as much mass as the sun, while in a normal nova the mass of the expanding gases is only about 10^{-5} or 10^{-6} the sun's.)

As the gaseous shell continues to expand, it encounters a certain amount of interstellar matter, which may be regarded as stationary with respect to the planetary. The shell sweeps up the interstellar atoms and dust particles, and they tend to slow the expansion and to condense the outer parts of the nebula. This explains why many planetaries have well-marked outer edges, which do not gradually fade away as might be expected if the nebula were expanding into a vacuum.

In its earliest stages the shell was fairly dense, and it was expanding at a larger velocity than at present. Gurzadian believes the initial speed of outflow was 100 kilometers per second or somewhat less (very much smaller than the velocity of expansion of a typical nova or supernova). At first the expanding shell suffered practically no braking action from the surrounding interstellar medium. Thus for a time the nebula grew at a constant rate, but meanwhile the density decreased, and finally the resistance from the interstellar material became significant.

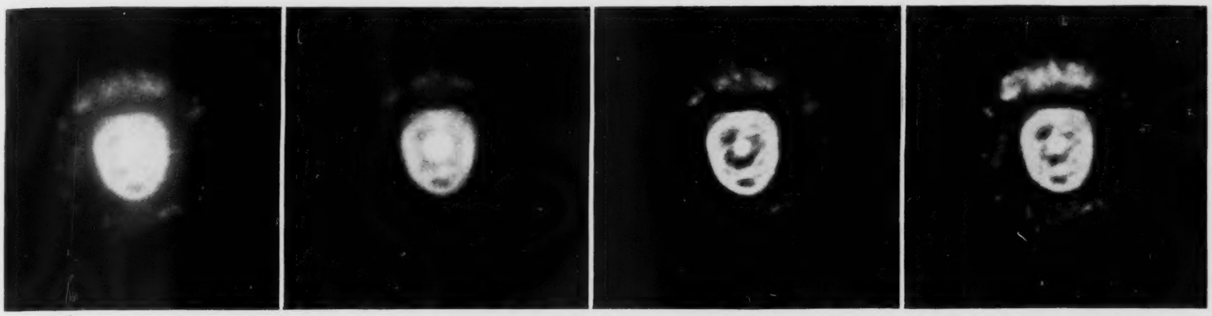
Now let us suppose that the shell was not exactly spherical at the start, but had bulges and hollows in its surface. Then this irregular shape would remain unaltered as long as the braking action of the interstellar medium was negligible. But how would the shape be affected when the resistance became appreciable? To solve this problem requires a complicated hydrodynamical study, but Gurzadian's physical ideas are relatively simple to understand.

Long after Nova Persei brightened to magnitude zero in the year 1901 and faded again, the gaseous shell ejected during that great stellar explosion could be directly observed. This picture was taken some 48 years later, in 1949, with the 200-inch telescope, and shows that the shell's disintegration is far advanced. Such rapidly expanding nova shells contain far less mass than planetary nebulae. Mount Wilson and Palomar Observatories photograph.

He attempts to answer the question: Will the braking action of the surrounding medium tend to shrink the bulges along the outer surface of the shell, or will it tend to exaggerate them? In the first event the shell would remain stable, retaining its ringlike appearance. In the second case, the shell would become unstable and would ultimately break up into a series of detached blobs of gas resembling in structure the large diffuse nebulae of the Milky Way.

Up to the time when the resistance of the interstellar medium becomes significant, the bulges and hollows expand together with equal speed—that of the initial outburst from the central star. Because they extend farthest from the star, first the bulges enter the region where the resistance acts, and some time later the hollows enter the same region. But because of the expansion, the over-all density of the shell is decreasing steadily, and when a hollow reaches the critical distance from the star, it has a smaller density than that a bulge had at the start of the deceleration. Therefore, the hollow experiences a greater retardation from the interstellar material, and the bulge moves forward faster than the hollow. The irregularities in the shell's surface become more pronounced; the nebula becomes unstable and must break up into detached clouds.

Gurzadian has computed the radius of



The planetary nebula NGC 2392 in Gemini, photographed in ultraviolet (left), violet, green, and red light, with the 200-inch telescope. The third image from the left records the radiation of doubly ionized oxygen at wave lengths of 4959 and 5007 angstroms. The faint outer portions of this double-ring planetary show an irregular structure suggestive of the breakup considered by Gurzadian as the ultimate fate of planetary nebulae. Mount Wilson and Palomar Observatories photograph.

the shell when instability sets in; in centimeters it is approximately equal to the cube root of the ratio of the total mass of the nebula (0.1 sun or 2×10^{32} grams) to the density of the interstellar medium (5×10^{-24} grams per cubic centimeter). The result is $(2 \times 10^{32}/5 \times 10^{-24})^{1/3}$ or 3×10^{18} centimeters—about 200,000 astronomical units. This value, Gurzadian remarks, is close to the limit of size actually observed among the well-defined planetaries. According to B. A. Vorontsov-Velyaminov, there are only nine planetary nebulae out of 132 whose radii exceed 100,000 astronomical units.

If we make the same computation for a typical nova in which the expelled mass is only 10^{-5} solar mass or 2×10^{28} grams, the nova shell is found to become unstable when its radius has become about 10,000 astronomical units. With the rapid expansion typical of novae, this size will be reached in about 30 years. Thus, the shell of Nova Aquilae (1918) may be expected to reach the stage of instability at the present time, while the shell of Nova Persei (1901) is already unstable—as indeed the observations seem to show. Gurzadian concludes that the planetaries cannot be regarded as the end products of ordinary nova explosions. On similar grounds he also rules out the Wolf-Rayet stars and the supernovae as possible ancestors of the planetary nebulae.

How long can a planetary last before it breaks up into separate blobs of material? This begins to happen, as we calculated above, when its radius is about 3×10^{18} centimeters. The average velocity of expansion may have been about 50 kilometers per second, which is 5×10^{6} centimeters per second. Dividing the radius by this velocity gives 6×10^{11} seconds, or about 20,000 years for the lifetime of a planetary nebula until it begins to disintegrate.

Thus the planetaries are old compared with the few observable nebulous shells of novae, but when compared with the evolutionary cycles of even the hottest stars they are exceedingly short-lived. This, in turn, explains why there are so few observable planetaries at the present time.

Gurzadian estimates that the ancestors of the planetary nebulae must be extremely rare in space—about 10^{-10} objects per cubic parsec. By contrast, in the vicinity of the sun there is one star per cubic parsec. Recently, G. H. Herbig has made the interesting tentative suggestion that the rare variable stars of the R Coronae Borealis type may in fact be the earliest stages of the planetary nebulae.

(To be continued)

WHITE DWARF BINARY STARS

Thirty-two double stars are now known that contain white dwarf components, according to W. J. Luyten, University of Minnesota. Binaries among such systems provide our sole direct means for determining the masses of white dwarf stars. But so far the necessary information about orbital motion and distances is sufficient in just three cases—the companions of Sirius, Procyon, and Omicron^2 Eridani.

Of the other 29 pairs, 14 already show orbital motion, but another five may be merely optical doubles instead of binary systems. Only one double star is listed in which both members are white dwarfs. This is LDS 275 in the constellation Antlia; it consists of two 15th-magnitude stars 3.7 seconds of arc apart. Dr. Luyten suspects that their period of orbital motion is about 700 years.

Only one spectroscopic binary star is known that has a white dwarf member. This system is a 14th-magnitude member of the Hyades cluster. Known as HZ 9, its binary nature was detected by Jesse L. Greenstein at the Palomar Observatory. Should HZ 9 turn out to be an eclipsing system as well, it would provide an unprecedented opportunity to measure directly the diameter of a white dwarf star.

Dr. Luyten presented his survey at the conference on binary stars held last August at the Dominion Astrophysical Observatory, Victoria, B. C. It has recently been printed as a publication of the University of Minnesota Observatory.

GEOMAGNETIC CHANGES AND RADIOCARBON DATING

An important factor in radiocarbon dating of historical artifacts and other old materials may be the changes that have occurred in the earth's magnetic field since ancient times. This is pointed out in the December 1, 1956, issue of *Nature* by three American geophysicists, W. Elsasser, University of Utah, and E. P. Ney and J. R. Winckler, University of Minnesota.

They call attention to laboratory studies by E. and O. Thellier in France, who measured the residual magnetism of ancient bricks, including some from Gallo-Roman ruins of about A.D. 200. From these measures, the French scientists could deduce the intensity of the earth's magnetic field at the dates when the bricks were baked. They found that the total intensity of the magnetic field in France has dropped by 65 per cent in the past 2,000 years.

If this decline in the geomagnetic field has been world-wide, the amount of cosmic radiation reaching the ground has risen during the same period, because the field is becoming a less effective shield against the incoming charged particles that constitute cosmic rays.

And if cosmic rays are becoming more intense, their bombardment of the atmosphere should be producing an increasing amount of radioactive carbon of atomic weight 14. This would mean that the dating of archeological materials by measuring their carbon-14 content is giving erroneous results, for this method of dating assumes that radiocarbon was produced in the past at the same rate as it is today. The effect would be to make an object actually 2,000 years old appear to be about 240 years older than that.

Furthermore, a progressive change in the over-all magnetic field for longer periods of time than the nearly 2,000 years covered by the Thellier data would give rise to much larger discrepancies, amounting to as much as 1,000 years for an object whose true age was 4,000 years.

AMERICAN UNIVERSITY OBSERVATORY

Owen Gingerich
American University Observatory
Beirut, Lebanon

The American University Observatory. The heliostat for the spectroheliscope is to the left of the entrance, while the portable Zeiss refractor is at the right end of the observatory building.

IN THE CAPITAL city of the Lebanese Republic, the observatory of the American University of Beirut overlooks the eastern Mediterranean from a high vantage point on the campus. Founded in 1874, this is one of the oldest observatories operating in the Middle East, and after some years of neglect is now becoming one of the popular places on the university campus.

The present brown sandstone building was completed in 1895. It contains offices, a library, an astronomical laboratory, transit instruments, and a 12-inch refractor built by Warner and Swasey with photographic and visual lenses by John A. Brashear.

In those days every senior in the university was required to take astronomy, and pure research was fostered at the observatory. Under the directorship of Robert H. West, meteorological observations begun in 1874 were continued and a Milne seismograph was set up.

The famous Mount Wilson astronomer, Alfred H. Joy (now retired), began his career in astronomical photography at the American University Observatory. His series of plates of Halley's comet in 1910 is still preserved in the files. Following World War I, Julius A. Brown became director. He studied variable stars not only on plates taken with the 7-inch photographic doublet at Beirut but on plates procured from Mount Wilson and Harvard. Brown also helped develop several seismographs, and in 1929 borrowed a spectroheliscope from the Carnegie Institution of Washington; with this instrument measurements of solar emission features have been made.

Today, following a time of considerable neglect during World War II, a program of research is being re-established. Beirut's unusual number of clear days permits drawings of sunspots to be made almost every morning with the finder of the 12-inch telescope. The observations and their reduction are supervised by the associate director, Prof. Georgio Contino, who instituted this program several years ago. Current plans call for renovation of the spectroheliscope so that early-morning flare patrols will be possible; perhaps in the future a quartz polarizing monochromator can be used for solar work with the 12-inch.

The only research project directly utilizing the large refractor at present is the measurement of double stars by Prof. Contino with a filar micrometer. Other accessories to this telescope are a camera, grating and prism spectroscopes, and a polarizing photometer, now used primarily for instruction. We are working on a photoelectric photometer with which to test seeing conditions to determine if a more elaborate photometer would be feasible for 12-inch observations.

Also available for instruction are a traditional clock-transit-chronograph arrangement and a prime-vertical instrument, but the latter has suffered with the passage of time and for the next few years will give way to a neutron pile for neutron counts to be made by the physics department, as a contribution to

Owen Gingerich, director of the American University Observatory, lectures to students at an open night. Prof. Georgio Contino, associate director, is at the right, wearing a bow tie. Photograph courtesy "Al Kulliyah" magazine.

the International Geophysical Year. The 7-inch photographic doublet and a 9-inch reflector are at present unmounted.

The observatory library includes most important astronomical publications, and has long runs of meteorological and seismological serials. Fresh interest in the dormant seismological program was aroused by the destructive earthquakes in Lebanon in the spring of 1956; if the enthusiasm does continue, three-component seismographs may be purchased and installed in the observatory within the next few years.

Starting a year ago, a monthly series of open nights was initiated, and over 1,000 persons, mostly students, have looked through the refractor. Visitors can view the illuminated transparencies in the observatory hallway; at the foot of the stairs three successive "steps" outward in space are represented by the moon, a diffuse nebula in Scutum, and the spiral galaxy M101. An ultraviolet-light model of the nearest stars, built by the astronomy students according to instructions in the October, 1955, issue of *Sky and Telescope*, page 496, has attracted a good deal of attention from visitors.

The American University of Beirut has recently begun expanding its graduate school, although no graduate courses in astronomy are contemplated. But the observatory research potential will be strengthened by the growing recognition of the stimulus of pure research in a university environment. The next decade should show a considerable growth in the observatory's program and facilities.

IN THE CURRENT JOURNALS

HIGH ALTITUDE RESEARCH, by Eric Burgess, *Journal*, British Interplanetary Society, September-October, 1956. "Before man can hope to achieve interplanetary missions and to establish permanent satellites he must have more accurate knowledge concerning the structure and composition of the terrestrial atmosphere at extreme altitudes."

THE AMATEUR SCIENTIST, *Scientific American*, January, 1957. "About amateur observations of the aurora during the International Geophysical Year."

THE EFFECT OF METEORIC PARTICLES ON A SATELLITE, by S. F. Singer, *Jet Propulsion*, December, 1956. "The effects of large meteors, those having a mass of more than a microgram, will be to penetrate thin skins of satellites or space ships upon impact —a microgram meteor penetrating approximately one millimeter of aluminum skin. On the other hand, the much smaller and less energetic micrometeorites will not be able to penetrate a skin of this thickness but instead will gouge out small pieces of the skin, a process which is very similar to sandblasting."

NEWS NOTES

THE SOLAR AUREOLE

Even on clear, haze-free days, the sun appears surrounded by an aureole of light—greatly increased sky brightness in the vicinity of the sun caused by the scattering of light by molecules and particles in our atmosphere. This effect is a major obstacle in observing the solar corona except at total eclipses of the sun.

Measurements of the brightness of the solar aureole have been carried out by Gordon A. Newkirk, Jr., High Altitude Observatory, at five mountain sites in Colorado ranging in altitude from 5,420 to 12,450 feet. His observations were photographic, made with a small portable coronagraph which had a focal ratio of f/100 and a field six degrees in diameter. On the same film that recorded the sky, a piece of opal glass illuminated by the solar disk was photographed as a photometric calibration mark, thus permitting measurements of relative brightness. The observations were made with four color filters from the blue to the infrared.

At a distance of two degrees from the center of the solar disk, the brightness of the aureole in blue light is 1/100,000 that of the sun, for an elevation 10,000 feet above sea level. Dr. Newkirk found that the aureole brightness decreased tenfold between the lowest and the highest of the stations from which he observed.

Most of the light in the aureole comes from scattering by relatively large particles, he concluded. The sky brightness around the sun was least on days when cool, fresh air was sinking; it was greatest when warm or stationary air masses were present. Dr. Newkirk's study is reported in the December, 1956, issue of the *Journal* of the Optical Society of America.

AURORAL PATROL SPECTROGRAPHS

Systematic observations of the spectrum of the aurora and the airglow of the night sky form an important part of the program of the International Geophysical Year. It is planned to install nearly two dozen auroral patrol spectrographs at widely separated places over the earth, with the greater number in the zones of maximum auroral frequency.

In Antarctica, patrol spectrographs are being set up at Byrd Station, Little America, Pole Station, Fourth Station (Weddell Sea), and Fifth Station (Knox Coast). In the United States they will be located at Billings, Montana; Chicago, Illinois; Ithaca, New York; Sunspot, New Mexico; and Williams Bay, Wisconsin. There will be one at Thule, Greenland, two in Alaska, and two in New Zealand.

Each spectrograph is housed in a weatherproof upright steel box $4\frac{1}{2}$ feet high and 1-by-$1\frac{1}{4}$ feet in cross section, surmounted by a dome covering an all-sky lens that images the heavens from horizon to horizon. Light from a meridional strip of sky two degrees wide is admitted to the grating spectrograph, and the spectrum is recorded by an f/0.625 Schmidt camera on 16-mm. film. The range of wave lengths that can be covered by the instrument is from 3500 to 8800 angstroms. The Perkin-Elmer Corp., designer and builder of the equipment, has adapted a laboratory-type instrument to function in the extremes of temperature that may occur—with a range of 165 degrees from the poles to the equator.

The working of each unit is wholly automatic. A timer starts its operation after dusk and stops it before dawn. The length of exposure is controlled by a photon counter, which closes the shutter when the accumulating sky brightness has reached a predetermined total. On a dark night an exposure will be obtained every six or eight hours, but during a strong aurora, when the photon count builds up more rapidly, many more spectrum photographs will be taken. But if the night is so very bright that normal aurora and airglow would be drowned out (as by moonlit clouds), a "twilight eliminator" goes into action and closes a shutter over the slit until the brightness level drops to the proper value.

THOMAS GOLD JOINS HARVARD STAFF

Thomas Gold, chief assistant to the Astronomer Royal of Great Britain for the past four years, has become a professor of astronomy at Harvard University. Immediately preceding his appointment, Mr. Gold was a visiting professor at Cornell University, lecturing on cosmic radiation and radio astronomy.

Known for his theoretical and instrumental studies in a wide range of astronomical phenomena, Mr. Gold is one of England's group of cosmologists that advanced the thesis of continuous creation of matter in the universe. He also demonstrated the possibility that dark regions on the moon may be great dust layers (see page 224).

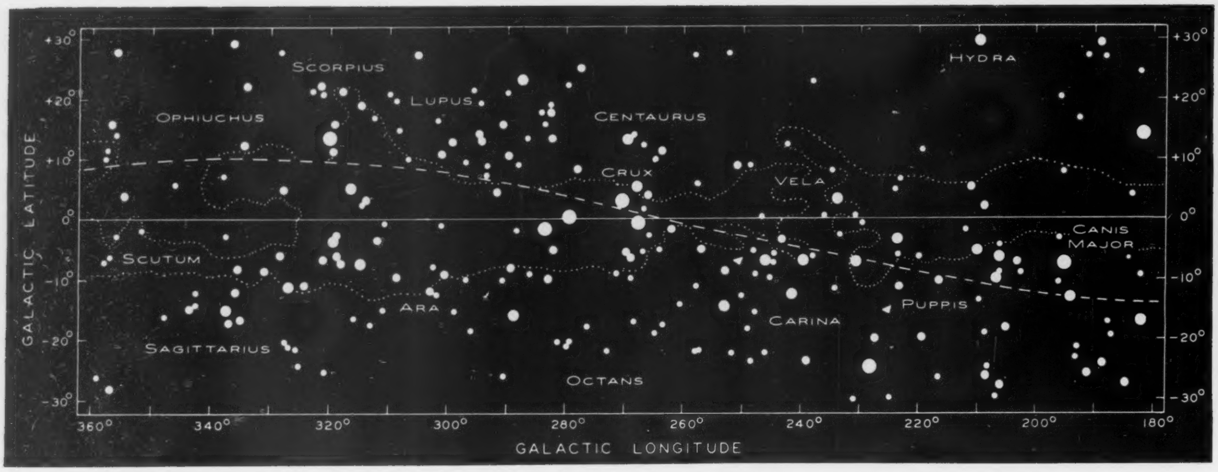
RUMFORD AWARD

Subrahmanyan Chandrasekhar, professor of theoretical astrophysics, University of Chicago, will receive the 1957 biennial Rumford Premium award of the American Academy of Arts and Sciences, at its meeting in Boston on March 13th.

The award will honor Dr. Chandrasekhar's extensive work on the radiative transfer of energy in the interiors of stars and in stellar atmospheres.

CORRECTION

On page 164 of the February issue, in the first line of the last column, for 7×10^6 read 7×10^5 parsecs.



Stars along the Milky Way, including those as faint as magnitude 4.2, are plotted in this chart and the one opposite. Note the tendency of bright stars to crowd toward the dashed curve, which marks the central line of the brighter B stars. More of this curve lies south of the galactic equator (horizontal axis labeled 0°) than to the north, indicating that the sun is situated a little on the northern side of the plane of Gould's belt.

The Local System

GEORGE S. MUMFORD, III, *Tufts University*

GREAT STRIDES have been made in recent years in delineating the spiral structure of our galaxy. Among the outstanding contributions are studies of the spatial distribution of blue stars by W. W. Morgan and his associates, and the radio observations of the Dutch.

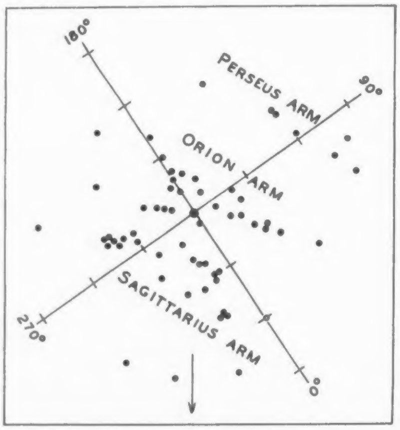
Three sections of spiral arms have now been observed in the vicinity of the sun. We are located on the inner edge of the Orion arm, which includes the blue supergiants and the hydrogen clouds of Orion, as well as the North America nebula in Cygnus. The more distant arm includes the Double Cluster in Perseus, while the Sagittarius-Scorpius nebulae lie in the arm between us and the center of our galaxy.

This is, to be sure, a more precise description of the sun's position in the galaxy than possibly could have been given some years ago, when all we knew was that the sun occupies an eccentric position some 9,000 parsecs from the galactic nucleus. But the new facts are still extremely general.

An astronomer's position is similar to that of a city dweller who has never left home. Such a person knows how far he is from the center of town, knows what his immediate neighborhood is like, but has little idea of his environs half a mile away. We know precisely where we are located in the solar system; however, beyond that no one is willing to be too specific. Is the sun in a condensation on the edge of a spiral arm? Is it in an offshoot of a spiral arm? Exactly what is our location in the galaxy? To answer these questions we must investigate fully all evidence for local structure.

GOULD'S BELT

Over a century ago, in 1847, Sir John Herschel pointed out a rather remarkable feature of the distribution of bright stars. He noticed that in the winter sky those of Orion, Taurus, and Canis Major are well to the south of the galactic plane, while in the summer sky the brighter stars are to the north of the plane, in the constellations Cygnus, Lyra, and Scorpius. Apparently the bright stars are spread out along a great circle inclined at an angle of about 20 degrees to the plane of the Milky Way.



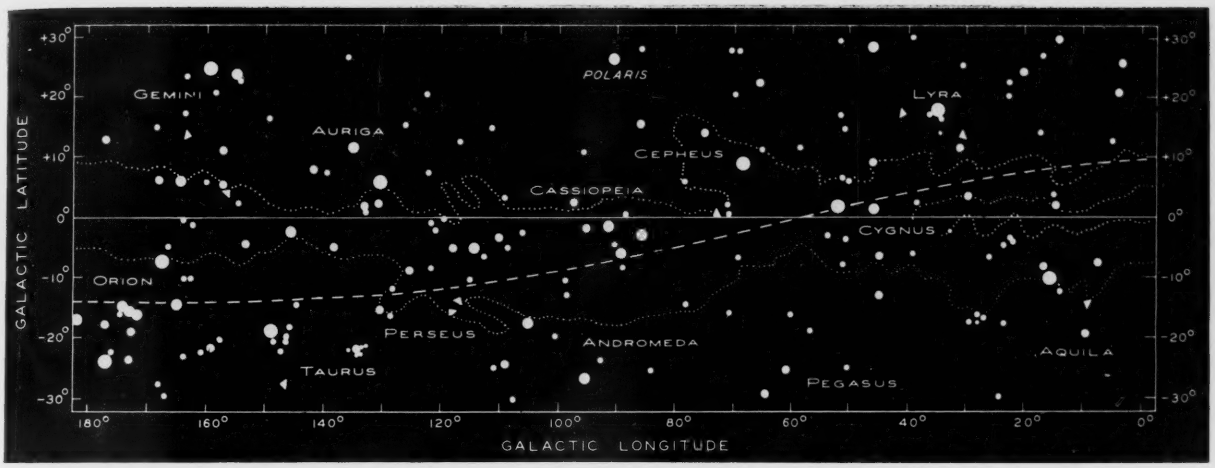
The arms of the galaxy in the vicinity of the sun are indicated by hydrogen emission nebulae (plotted as dots). The sun is the disk at the center of the lines showing galactic longitude, and these are marked at 1,000-parsec intervals. The arrow indicates the direction to the galactic center. Adapted from a diagram based on the work of Yerkes and Harvard astronomers, published in "The Milky Way," by Bok and Bok, Harvard University Press, 1957.

Some 30 years later, B. A. Gould, an American astronomer who was then the director of the Cordoba Observatory in Argentina, drew further attention to this phenomenon. In the introduction to his star catalogue *Uranometria Argentina*, he wrote about a band of especially conspicuous southern stars, beginning with those of Orion and including the brightest in Canis Major, Columba, Puppis, Carina, Crux, Centaurus, Lupus, and the head of Scorpius. He noted that while the course of the band is indistinct in the northern hemisphere, its direction is indicated by the brightest stars in Taurus, Perseus, Cassiopeia, Cepheus, Cygnus, and Lyra.

The approximate central line of Gould's belt is designated by the dashed line on the accompanying charts of the constellations in and near the Milky Way. The solid line represents the galactic equator, and corresponds to the horizontal axis of the Lund Observatory chart in the center section of this issue.

Gould suspected this apparent arrangement of the brighter stars indicated that the sun was in a small cluster, comparable to the Pleiades in size, distinct from the larger organization of the Milky Way. Distances between the stars involved are actually too great, however, to support this explanation.

At Lund in 1916, C. V. L. Charlier pointed out that Gould's belt is most strikingly evident for the stars of spectral type *B* visible to the naked eye. This



The brighter naked-eye stars of the Milky Way constellations are plotted in this chart and the one opposite.

point was emphasized in 1924 by H. Shapley and Miss A. J. Cannon, whose diagrams are reproduced below. The left half shows that the *B* stars brighter than 5th magnitude exhibit the effect clearly—at the center of the diagram, in the direction of Orion, the stars are most numerous about 15 degrees below the plane of the galaxy. In the other diagram the faint *B* stars behave quite differently, preferring the central line of the Milky Way. We can therefore conclude, as two more recent investigations confirm, that Gould's belt is a local effect.

J. J. Nassau and Morgan's 1950 survey of highly luminous *O* and *B* stars between visual magnitudes 6 and 10 near the galactic plane showed these stars to have an apparent distribution similar to that of Shapley and Miss Cannon's faint *B* stars. On the other hand, the distribution for 27 stars brighter than the limits of the survey (hence within 400 parsecs of the sun) indicates that the nearby *O* and *B* stars also lie along a fairly well-defined plane inclined at about 20 degrees to that of the galaxy.

Just last year, A. Blaauw published a comprehensive study of the distances and motions of northern *O* to *B*5 stars between galactic longitudes 340° and 200°. Gould's belt is clearly marked by the stars within 200 parsecs, and these are more numerous between longitudes 80° and 200° than between 340° and 80°. The relative motions of the stars between longitudes 80° and 170° are very small compared to their systematic motions with respect to the sun; they are members of Blaauw's "Cassiopeia-Taurus group." As few more distant *O* and *B* stars are found between longitudes 90° and 140°, the Cassiopeia-Taurus group may be a more-or-less isolated system. The distribution is shown in Blaauw's chart on page 217.

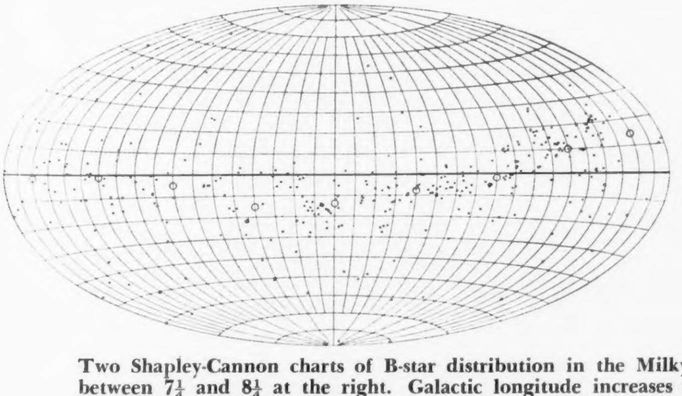
While Gould's belt is still prominent in the distribution of *O* to *B*5 stars at distances of 200 to 400 parsecs, two features are evident when we consider stars 400 to 600 parsecs away. First, there is a lack of *O* and *B* stars between longitudes 100° and 150°, which H. F. Weaver attributes to a break in the local spiral arm. Second, Gould's belt is no longer perceptible below longitude 150°, and, if it were not for the Orion association, would not be evident at all.

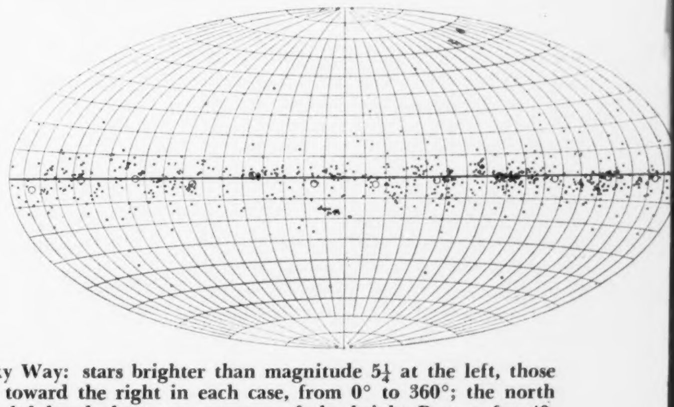
When we consider the acknowledged tendency for clustering among *B*-type stars, we should not be surprised to find that three of the four *B*-star aggregates within 600 parsecs of the sun lie along Gould's belt. These are the I Orionis, II Persei, and Scorpius-Centaurus associations; the I Lacertae association does not. According to Blaauw's work of 1946, the Scorpius-Centaurus association is the chief contributor in the southern hemisphere to Gould's belt.

Although Gould's belt is most prominent for the *B* stars, most of the 900 *A*0 stars between magnitudes 7.0 and 7.8 in the *Henry Draper Catalogue* show the same orientation. For later spectral types, however, there is generally little or no indication that the galactic plane is not the plane of symmetry for all stars.

Originally, Shapley considered all objects whose plane of symmetry deviated greatly from the galactic equator to be members of the local system. In 1922 Hubble discovered that the diffuse nebulae are distributed in two distinct belts, one coinciding with the Milky Way. The other, seen in the chart on the next page, closely matches Gould's belt, although the inclination seems to be somewhat greater than for the *B* stars. Particularly noticeable is the lack of diffuse nebulae with large positive (north) latitudes between longitudes 80° and 200°.

In addition to the diffuse nebulae, a few nearby dark nebulosities evidently





Two Shapley-Cannon charts of B-star distribution in the Milky Way: stars brighter than magnitude 5¼ at the left, those between 7¼ and 8¼ at the right. Galactic longitude increases toward the right in each case, from 0° to 360°; the north galactic pole is at the top in both charts. Open circles in the left-hand chart are averages of the bright B stars for 40-degree intervals of longitude. Adapted from Harvard Observatory Reprint No. 6, 1924.

belong to the local system. Those in Taurus and Orion fall on Gould's belt, as does the one in Ophiuchus. Undoubtedly because of the obscuration by the Ophiuchus nebulosity, Gould's belt is not a prominent feature of the stars in the northern summer sky, as B. J. Bok pointed out in 1937. This nebulosity covers an area of 1,000 square degrees from longitudes 320° to 0° and in latitudes 0° to 30°. The absorption is at least one magnitude between latitudes +10° and +30°.

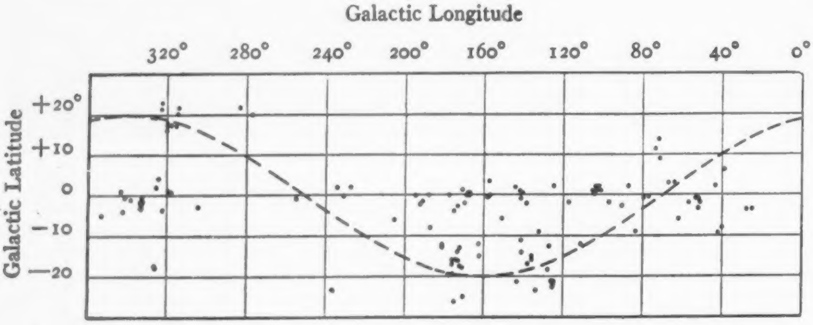
The apparent distribution of the dark nebulae is as striking as that of the diffuse ones. No dark clouds appear south of the galactic plane in the direction of the center of the galaxy, and none appear north of the plane toward the anticenter.

Radio Observations

The *B* stars, dark nebulae, and diffuse nebulae are all recognized tracers of spiral arms; therefore, it is not unexpected that Gould's belt has been detected by radio observations of the 21-cm. line of neutral hydrogen, considered by many to be the best of the spiral tracers.

Several years ago D. S. Heeschen and A. E. Lilley used the Harvard 24-foot radio telescope to study the 21-cm. line in the directions of the galactic center and anticenter, along a circle perpendicular to the galactic plane. The antenna tracked a fixed position while the receiver, which was tuned in frequency, recorded the brightness temperature in the hydrogen line as a function of frequency. The values of the peak brightness temperature for various galactic latitudes are shown in the accompanying diagram representing the results of the survey. As expected, the brightness temperature reaches its highest value in the galactic plane and then proceeds to drop off with increasing latitude. However, notice that there is also a concentration along a line inclined at about 20 degrees to the galactic plane, nearly coinciding with Gould's belt.

A concentration of neutral hydrogen clouds along Gould's belt is not surprising, in view of the interrelation between gas and dust previously pointed out by Lilley in 1955. He found the gas-to-dust density ratio for the dark clouds of Taurus, Orion, and Perseus to range from 35 to 250, with a mean of 100. The positions of high intensity of the hydrogen line at latitudes +20° and −20° coincide with regions of heavy obscuration. Apparently neutral hydrogen, as well as dust and early-type stars, is a constituent of the local system. Heeschen and Lilley further state that a good fraction of all matter near the sun must be concentrated toward Gould's belt.



This chart, published by Edwin P. Hubble in 1922, shows the distribution of diffuse galactic nebulae observable from Mount Wilson Observatory. They lie along two belts, one in the galactic equator, the other inclined about 20 degrees to it. From the "Astrophysical Journal."

The Local System

Thus far, evidence has been presented which indicates the existence of a local system, but nothing has been said concerning its shape. If we refer to the Shapley-Cannon left-hand chart, we notice that around longitude 60° there are fewer nearby bright *B* stars than in the opposite direction, toward Carina. This indicates, generally speaking, two possibilities. Either we are on the forward edge, in terms of galactic rotation, of a local condensation of *B* stars, or there is considerable obscuration in this direction. It is most likely that a combination of both effects is present. As early as 1929, A. Pannekoek had established that the sun occupies an eccentric position with respect to the nearby *B* stars.

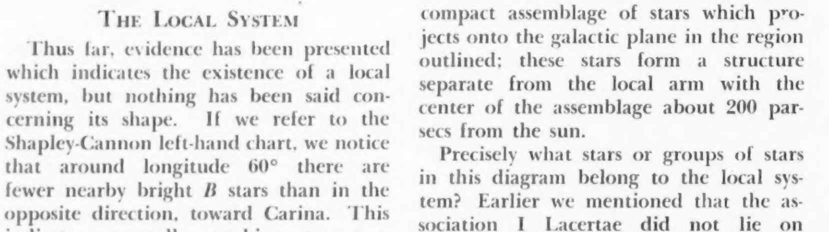
Two Russian astronomers, B. V. Kukarkin and P. P. Parenago, suggested that the sun is situated in a small local condensation (separate from the Orion arm), which is slightly elongated in the direction from Carina to Cygnus. The extension of the local system in these directions is clearly evident in studies of space density of *B*8-*A*0 stars. Bok finds that between longitudes 250° and 265° the number of these stars per thousand cubic parsecs increases steadily to a maximum at a distance of 1,000 parsecs, and then falls off. In the opposite direction, S. W. McCuskey found last year that the space density of *B*8-*A*0 stars attains a maximum within 500 parsecs of the sun.

In 1950, Nassau and Morgan placed the center of the local system in the direction of Carina, with the sun on the leading edge. They gave the diameter of the local system as 500 parsecs. At Bonn a year earlier, H. Schmidt found the same direction for the center of the system, with the sun located 100 parsecs from it; but the diameter of his system is 1,000 parsecs. As there always has been considerable uncertainty concerning the size of the local system, this problem must be investigated carefully.

The diagram by Blaauw shows the distribution of stars of spectral type *B*3 and earlier within 400 parsecs and between longitudes 340° and 200°, projected on the galactic plane. The dots represent stars in the Cassiopeia-Taurus group. Field stars are marked by plus signs if they are at positive galactic latitudes and by minus signs if they are below the galactic equator. The Scorpius-Centaurus stream consists of a rather compact assemblage of stars which projects onto the galactic plane in the region outlined; these stars form a structure separate from the local arm with the center of the assemblage about 200 parsecs from the sun.

Precisely what stars or groups of stars in this diagram belong to the local system? Earlier we mentioned that the association I Lacertae did not lie on Gould's belt; hence, a priori, it can be excluded from the local system. The remaining associations all fall along Gould's belt. The I Orionis association is in the Orion arm, and T. Matthews, working with the Harvard radio telescope, has recently shown that II Persei (and I Lacertae) also belongs to the nearby part of the Orion arm. Thus, if we include I Orionis and II Persei as members of the local system, then the diameter would be about the same as that of Schmidt's system (1,000 parsecs).

On the other hand, should we rule out gross spiral features from membership, and include only the Cassiopeia-Taurus



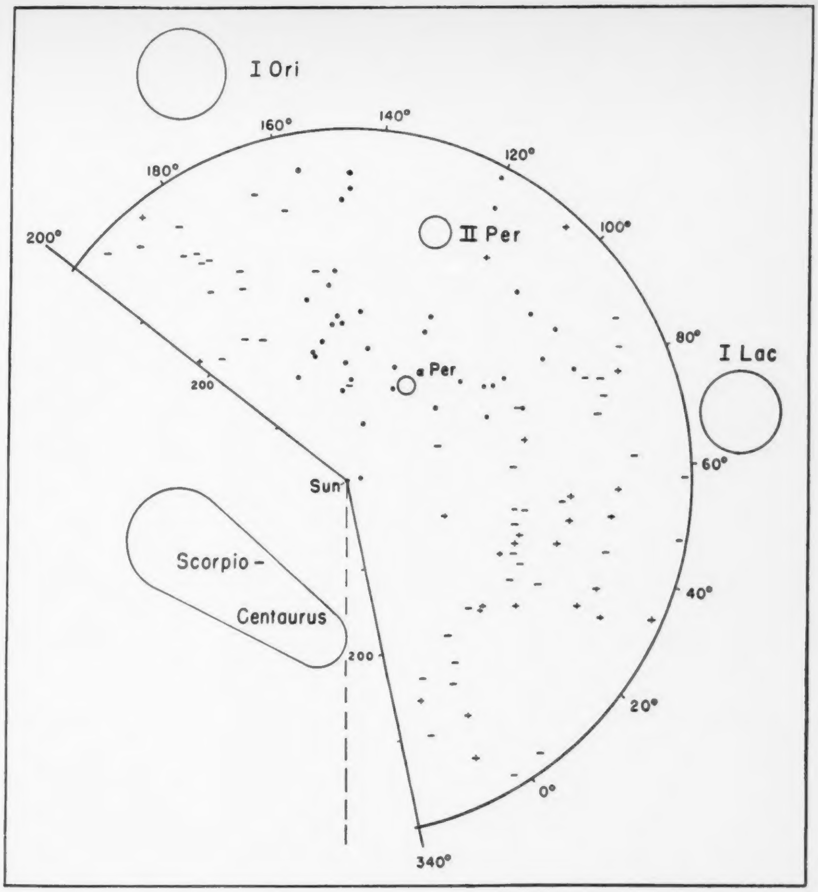
The distribution of peak brightness temperature with galactic latitude for a section perpendicular to the galactic plane at longitudes 327° and 147°, from 21-cm. observations by D. S. Heeschen and A. E. Lilley. From Harvard Observatory Reprint No. 396, 1954.

stream along with the Scorpius-Centaurus association (both of which Blaauw suspects to be isolated groups), we are dealing with a local system of the same order of size as Nassau and Morgan's (500 parsecs). Moreover, the eccentric position of the sun in this system is clearly indicated in Blaauw's diagram.

Is the second alternative the preferable choice? Matthews has made a radio survey in a strip at longitude 100°. His results were given as a plot of the number of hydrogen atoms versus galactic latitude. The curve is double peaked, the lesser peak occurring at about latitude −4°, extremely close to the position of Gould's belt at this longitude; the larger peak is definitely due to the nearby Orion arm. The reality of the double peak should be carefully investigated, for here may be evidence that Gould's belt is distinguishable from the nearby arm. If this is true, then certainly we are correct in omitting gross spiral features from membership in the local system.

A second reason for limiting the extent of the local system is based on the striking similarities between the distribution of the stars in the Scorpius-Centaurus association and those in the Cassiopeia-Taurus group. The centers of both are about the same distance from the sun; both are primary contributors to the phenomenon of Gould's belt in opposite parts of the sky. It would prove extremely interesting if these two groups were actually connected, with the Ophiuchus and Taurus nebulosities forming the connecting link.

To many astronomers, Gould's belt is weak evidence for the existence of a local system. Dr. Blaauw has pointed out, in private correspondence, that Gould's belt may be a feature similar to that observed in the Perseus arm. The 21-cm. line observations of the neutral hydrogen distribution show that the greatest extent of the elliptical cross section of the Perseus arm is neither perpendicular to nor in the galactic plane, but inclined to it. Equidensity lines for the cross section of this arm are drawn at the right. Local interstellar matter, for an observer at X, will appear to lie in a plane inclined to the galactic plane and thus cause a phenomenon similar to Gould's belt. In this case, Gould's belt is a manifestation of a far more general feature of galactic structure than a local system would be.



Nearby stars of early spectral type, from O to B3, are shown projected on the galactic plane. This chart by A. Blaauw represents a region that is very close to the sun, in contrast to the wider coverage of the chart of the spiral arms on page 214; here the large circle has a radius of only 400 parsecs. The associations shown by circles lie along the Orion arm, and the position of the Alpha Persei cluster is marked by "α Per." The dashed line points toward the galactic center. Reproduced with a few simplifications from an article by Dr. Blaauw in the May, 1956, "Astrophysical Journal."

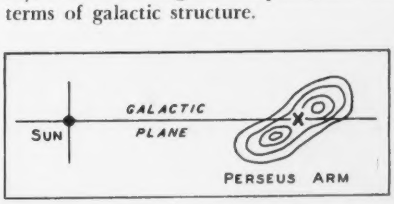
OBJECTS CONCENTRATED TOWARD GOULD'S BELT

1916	Charlier	*B* stars brighter than magnitude 6.0
1922	Hubble	Some diffuse nebulae; extended dark nebulae
1924	Shapley and Miss Cannon	*A* stars in *Henry Draper Catalogue*
1933	Merrill and Burwell	*Be* stars brighter than magnitude 6.25
1946	Blaauw	*O-B5* stars within 400 parsecs
1950	Nassau and Morgan	Luminous *O* and *B* stars within 400 parsecs
1954	Heeschen and Lilley	Neutral hydrogen
		Associations I Orionis, II Persei, and Scorpius-Centaurus

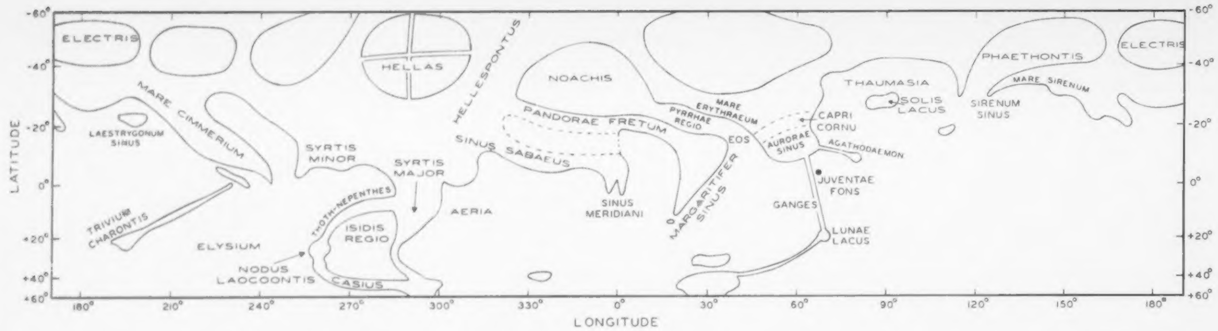
Our present knowledge of the types of objects that adhere to Gould's belt is summarized in the preceding table. As we have seen, it is probably necessary to apply the criterion of distance to each object before we can award it membership in the local system, if one exists.

While it is doubtful that the controversy over the existence or nonexistence of a local system will be resolved in the very near future, the problem will eventually succumb to a combination of radio and optical research. Moreover, only when attempts have been made to distinguish between spiral features and phenomena which may be related to a local system, and only after a careful investigation of a possible link between the Cassiopeia-Centaurus stream and the Ophiuchus and Taurus dark complexes has been made, will our knowledge be sufficient to permit us to state more definitely where the sun lies in our galaxy.

Regardless of future observational results, Gould's belt is still present in the sky, still awaiting an explanation in terms of galactic structure.



In the Perseus arm of the galaxy, recent 21-cm. studies indicate the neutral hydrogen to be distributed asymmetrically in cross sections perpendicular to the galactic plane. In a similar manner Gould's belt might not necessarily indicate the existence of a local system.



This key chart of Mars identifies features mentioned in the article, and may be compared with the drawings on the following pages. The vertical scale makes allowance for the foreshortening in high latitudes, but more for the northern than the southern hemisphere of the planet, as the south pole of Mars was tilted toward the earth during most of 1956. The chart is adapted from one prepared by Seymour L. Hess for the International Mars Committee, to be used in recording Martian clouds during the 1956 opposition. As on the earth, east is in the direction of decreasing longitude, on this chart to the left.

Some Observations of Mars in 1956

Thomas R. Cave, Jr.

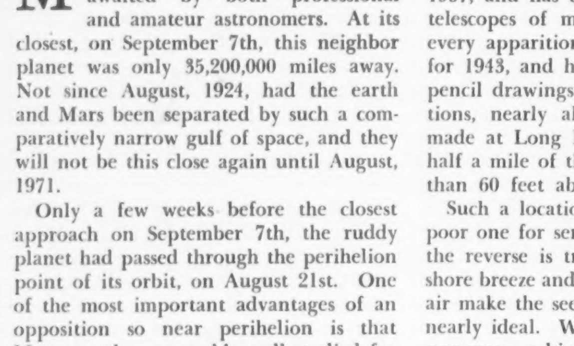
MARS' 1956 opposition was long awaited by both professional and amateur astronomers. At its closest, on September 7th, this neighbor planet was only 35,200,000 miles away. Not since August, 1924, had the earth and Mars been separated by such a comparatively narrow gulf of space, and they will not be this close again until August, 1971.

Only a few weeks before the closest approach on September 7th, the ruddy planet had passed through the perihelion point of its orbit, on August 21st. One of the most important advantages of an opposition so near perihelion is that Mars may be reasonably well studied for a rather long period. Most planetary observers agree that Mars can be fairly satisfactorily viewed when the planet's disk has a diameter of 10 seconds of arc or larger. In 1956 this condition prevailed for about seven months, from mid-May to mid-December. The apparent diameter of Mars on September 7th was 24.8 seconds, within 0.3 second of the maximum possible.

The writer began observing Mars in 1937, and has continued this work with telescopes of moderate aperture during every apparition since that time, except for 1943, and has made several hundred pencil drawings. For these nine oppositions, nearly all the observations were made at Long Beach, California, within half a mile of the Pacific Ocean and less than 60 feet above sea level.

Such a location might appear to be a poor one for serious planetary work, but the reverse is true. The prevailing onshore breeze and the moisture-laden ocean air make the seeing at Long Beach often nearly ideal. While clear nights are not numerous, a high percentage of them are favored with very good seeing.

Last year systematic observations of Mars were begun about the middle of June, as before that time predawn fog allowed only occasional views of the planet. Observations were attempted on nearly every clear night, and drawings were made whenever the seeing was good enough to reveal considerable fine detail distinctly. All drawings were accompanied by written notes, which were also often made when the planet was not sketched.

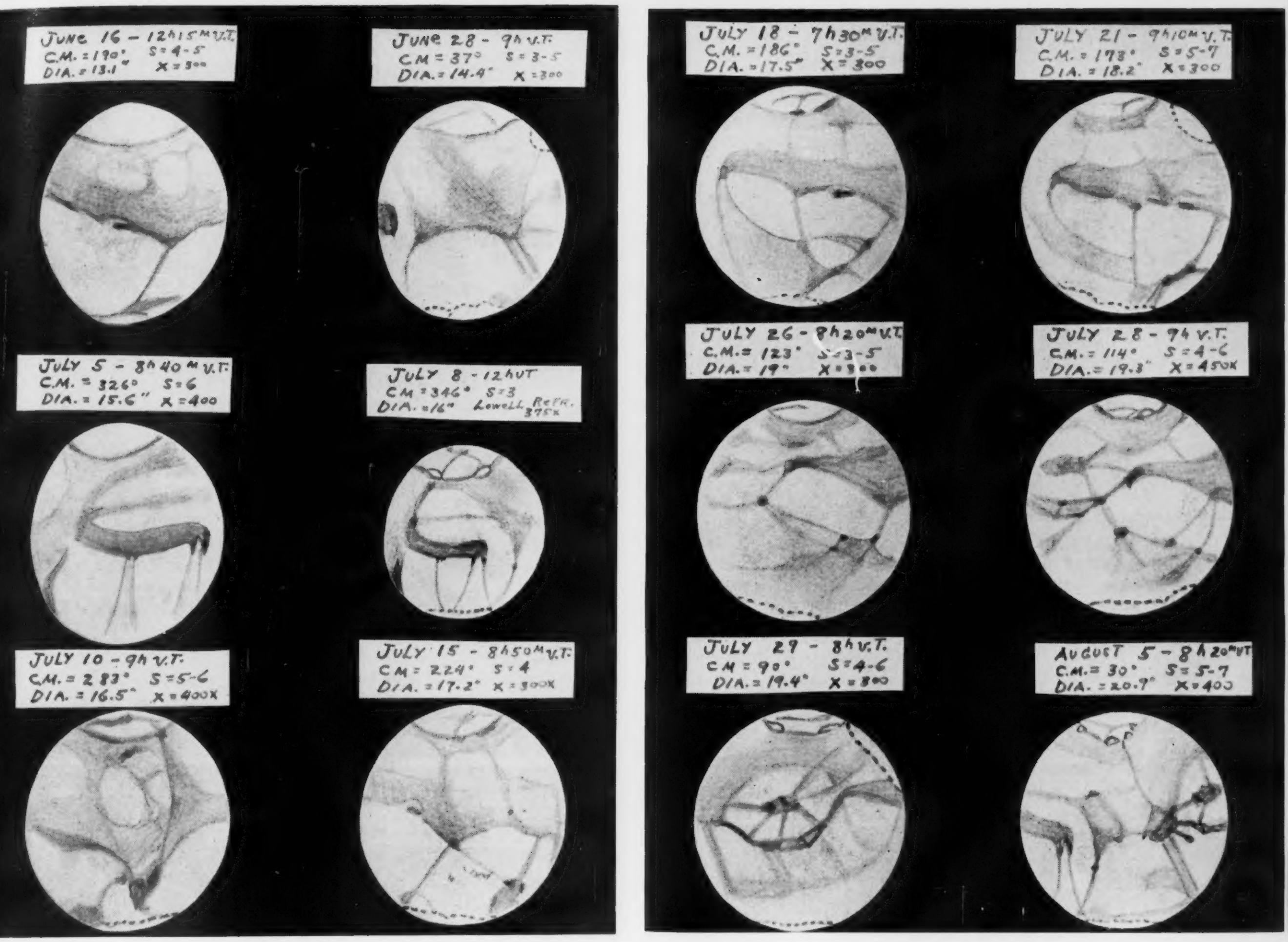


The Mountains of Mitchel are the bright detached spots just to the left of Mars' south polar cap, in this drawing by Nathaniel E. Green on September 8, 1877, at 12:30 Greenwich time. He used a 13-inch reflector, powers 200 to 400, on his Mars expedition to a mountain site on the island of Madeira. From the "Memoirs" of the R.A.S.

The telescope used on all but two occasions was my $12\frac{1}{2}$-inch Newtonian reflector, approximately f/6, which is equatorially mounted and has a clock drive and electric slow motions. Orthoscopic eyepieces were used exclusively, often with a good achromatic Barlow lens. Usually the magnification ranged from 225x to 450x, and very rarely exceeded 600x. From long experience, I have found this telescope performs admirably for planetary work.

The 1956 apparition of Mars will probably be regarded for many years to come as a remarkable but rather disappointing one. It was noteworthy for several extensive cloud areas, but there was very little contrast between the mare and desert regions of the planet. Obscuration in the Martian atmosphere was perhaps the main cause of this lack of easily visible detail. It is also possible that the surface markings themselves did not regenerate and darken as usual with the melting of the south polar cap. Undoubtedly most observers who used 8-inch telescopes and smaller seldom saw the normally dark markings easily and clearly. Telescopes larger than 8-inch showed the faded and tenuous details far better. I found that only a Wratten 23A (red), and at times a 25A (yellow), filter increased the contrast enough so some of the finer and fainter details could be glimpsed with certainty.

By the middle of June the Martian south polar cap was large and rather normal in appearance, with a definite blue-gray fringe surrounding it. On June 28th the first faint rifts appeared in the



This series of drawings of Mars in 1956 was made by Thomas R. Cave, Jr., with his $12\frac{1}{2}$-inch reflector, except on one occasion, when he used the 24-inch refractor at Lowell Observatory. The labels give the date and Universal time, the longitude of the Martian central meridian, the quality of the seeing on a scale of 0 to 10 (best), the apparent diameter of the planet in seconds of arc, and the magnification employed.

south cap, and the fringe began to darken. Early in July bright knots became visible around the edge of the cap, being much brighter at times than the cap itself. About the middle of the same month, darker areas in the blue fringe became very apparent; by then the dark rifts in the polar cap were very wide, and seemed to divide it into three or four sections. Near the end of July several bright spots formed just within the blue fringe of the rapidly melting cap. On a few occasions of excellent seeing these spots seemed to sparkle or scintillate; their rapid changes in brightness were exceedingly beautiful.

Although the south cap was following a normal melt pattern, by early August its outline became an irregular oval. Several small bright detached areas began to appear, very similar to those seen nearly 80 years ago by the English amateur N. E. Green on his expedition to the island of Madeira. His drawings of them were published in volume 44 of the *Memoirs* of the Royal Astronomical Society (1879). Green saw these detached areas appear at almost the same Martian seasonal date that I did.

On August 11th, at 7 o'clock Universal time, I obtained my first view of the famous Mountains of Mitchel, named after O. M. Mitchel, first director of the Cincinnati Observatory, who discovered them in 1845. These mountains appeared as a single, very elongated, detached strip of white, just outside the blue fringe surrounding the south polar cap. Five nights later, I saw the mountains separately as two tiny bright points of light, exactly as drawn by Green in 1877. I last observed them on August 19th; two nights later they had vanished.

By the second week in September the south cap seemed to have reached its smallest size, although it may have shrunk slightly more in early October. My last excellent view of the details of the south cap was on October 12th, when a very wide dark rift cut it in two, the western half being the brighter.

The north pole of Mars was tilted away from the earth between 19 and 25 degrees during the months favorable for observation in 1956. Therefore surface detail in the mid-northern latitudes of Mars was much foreshortened. On a great many nights mists and clouds were easily seen over the northern extremity of the visible disk, especially after mid-August, indicating the formation of the north polar cap.

Already mentioned as one of the most striking features of this apparition was the faded appearance of the usually dark maria. This was obvious as early as mid-June as a dull, washed-out texture of the maria, that to a great extent persisted throughout most of my observations. Shortly after the second week in August, much of the dark detail seemed for a very brief time to increase noticeably in contrast, but by the end of August the contrast was even lower than it had been in June and July.

In the following notes on the appearance of some individual markings, it is convenient to proceed westward around

the planet in the general order of Martian longitude. These markings can be identified on the key chart on page 218; see also Mars map in *Sky and Telescope*, September, 1956, pages 502-3.

The zero meridian of Mars passes through Sinus Meridiani (Dawes Forked Bay), which in 1956 was normal in outline and appearance except for its unusual faintness. Farther west, Margaritifer Sinus presented very nearly the same outline as in 1954; it was separated from the much darker Aurorae Sinus by the light areas Pyrrhae Regio and Eos. Aurorae Sinus appeared appreciably smaller than in 1954, being almost detached from Mare Erythraeum by a very light Capri Cornu. The tiny, extremely dark oasis, Juventae Fons, was many times visible on nights of fine seeing; I thought it easier than in 1954, but not as dark as in 1941, when it sometimes looked like a drop of black ink.

The ever-prominent Ganges canal was usually easy in fair seeing. It was the only "double canal" I saw. With nearly perfect seeing, as on October 12th at 4:40 UT, Ganges was very wide; its two edges were dark by contrast with the bordering desert, giving an appearance that would be interpreted under less favorable conditions as a double canal.

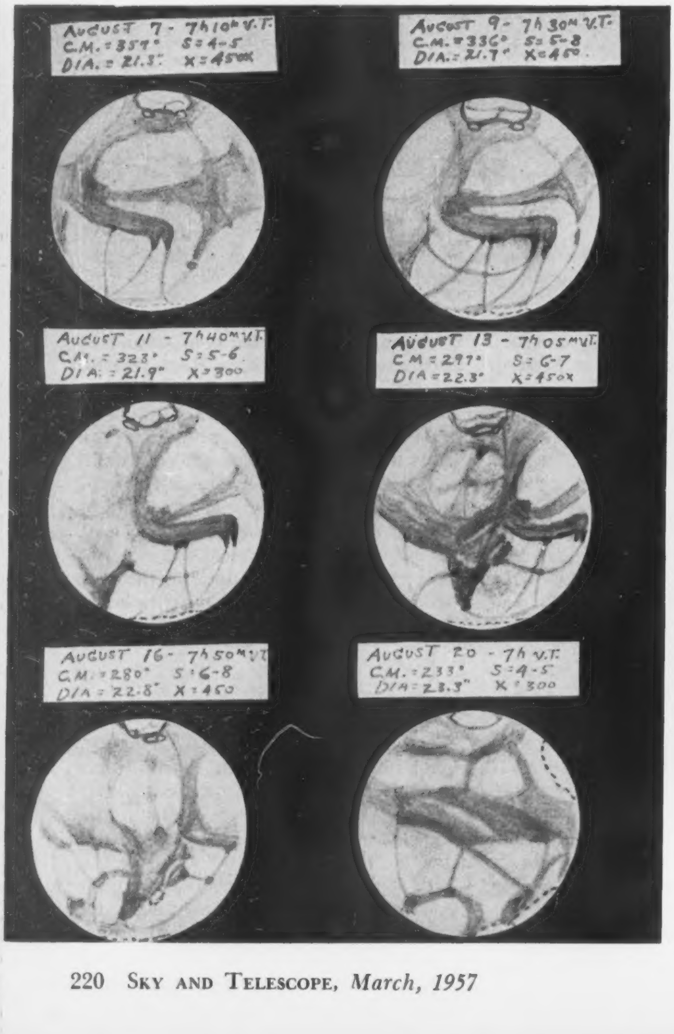
Between Martian longitudes 70° and 130° are the Solis Lacus and Thaumasia areas. These interesting regions were generally lacking in contrast. The darkest details were the complex system of tiny oases comprising Solis Lacus itself, and the Agathodaemon bridge some 20 degrees south of it.

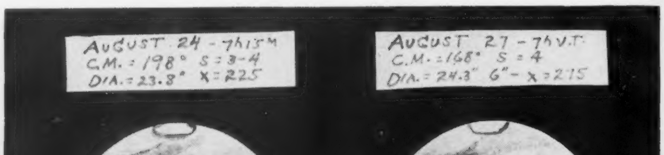
The curving end of Sirenum Sinus—the easternmost part of Mare Sirenum—was very prominent on a number of occasions. With excellent seeing, the northern border of Mare Sirenum was frequently resolved into carets or tiny extended knots. Two light regions, Phaethontis and Electris, were well presented because the Martian south pole was strongly tilted toward the earth; sometimes they appeared as white as the south polar cap. During most of this apparition, Laestrygonum Sinus at longitude 200° strongly resembled its 1939 and 1941 appearance, being nearly separated from the adjoining mare by a narrow peninsula of desert.

Far to the north and much foreshortened in all 1956 views were Trivium Charontis and the very large white oval area, Elysium, just west of it. These features were seen always skirting the mists of the cloud-enveloped north polar regions. West of Elysium, and bounded on the west by Thoth-Nepenthes and Casius, is the large new dark area, Nodus Laocoontis, that attracted so much attention in 1954. (It was described by Tsuneo Saheki on page 442 of *Sky and Telescope* for August, 1956.) Nearly the size of Texas, it was still very prominent in 1956, being plainly seen on a number of nights. But since it lies nearly in the same latitude as Trivium Charontis, it was not as well placed for viewing as two years ago.

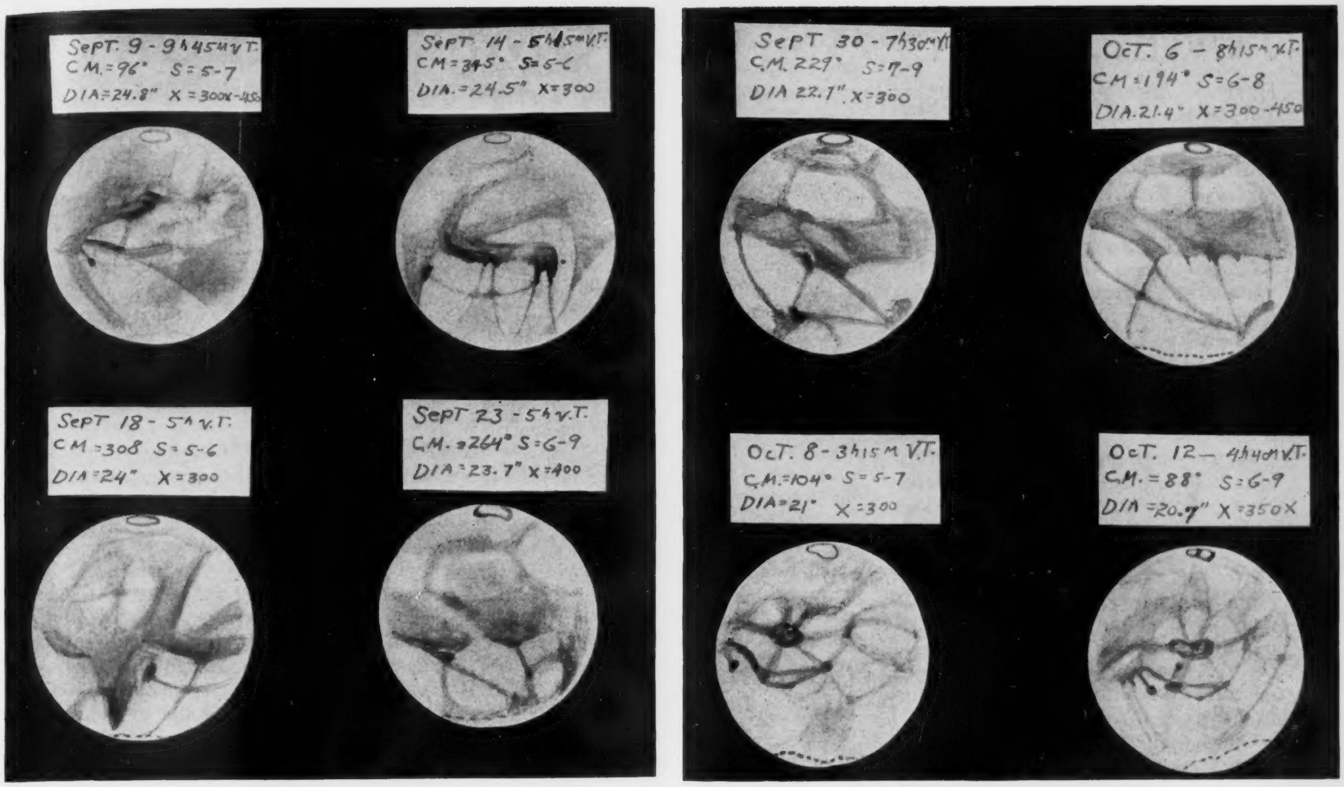
One of the best known of all Martian features is the great Syrtis Major, rich in detail and usually very dark. Its outline was rather normal, but contrast was lacking. An interesting minor development in this area was a new dark extension barely detached from the west border of Syrtis Major, centered roughly at longitude 305°, latitude +12°. Syrtis Major as a whole darkened appreciably between early July and late August; it was unusually light (obscured) about mid-September, darkening again in October and November.

Well to the south of Syrtis Major is the large white oval, Hellas. This area was unusually interesting to me. During





Mr. Cave's pictorial record of Mars in 1956 is here continued from August 7th to September 5th. On the drawing of August 16th, Hellas is the large light oval just above the center of the disk, in which the famous "Hellas cross" is recognizable. On September 4-5, the very broad canal Ganges appeared in the lower left part of the disk.



Eight Cave drawings of Mars cover the interval from the day before the 1956 opposition to four weeks afterward.

the last decades of the 19th century Schiaparelli and other leading observers often represented Hellas as crossed by two linear markings. As early as August 11th last year, I obtained striking views of these during brief moments of steady air, and the "Hellas cross" persisted for the rest of the apparition.

Hellespontus, an area famous for its seasonal changes, darkened noticeably between July 10th and August 11th, and continued to intensify until nearly October. North and west of this is Sinus Sabaeus, the long, narrow, curving, dark band which terminates in Dawes Forked Bay. During 1956 Sinus Sabaeus generally had its expected appearance, except for a brief interval in mid-September when the portion between longitudes 340° and 350° faded appreciably. In other years, Sinus Sabaeus has been paralleled by Pandorae Fretum, another dark strip about 10 degrees farther south. This time, however, the latter originated in Sinus Sabaeus and curved southwestward to meet the southern part of Margaritifer Sinus.

Over 50 canals were observed and later identified on the 1954 ALPO map of Mars. In appearance they ranged from wide, vague streaks to very narrow, well-defined lines. My strong conviction is that in the best seeing they appear perfectly straight and very sharply defined, showing no sign of resolution into disconnected detail. The real canals should not be confused with the wide, soft, almost mare-like markings sometimes misnamed canals, which quite possibly are resolvable. With the possible exception of Ganges, no canals were observed as double. I saw nearly 40 of the oases, which did not seem nearly as difficult objects as at previous oppositions.

At least two major Martian cloud areas were observed during the weeks when Mars was closest to the earth. On August 20th, at about 7 o'clock UT, a very extensive white cloud appeared in the northern hemisphere, over Isidis Regio and obscuring the northern part of Syrtis Major. When last seen, two nights later, it extended into Aeria. It was brighter than the south polar cap on all three evenings that I saw it.

The other cloud I first saw on August 30th, near longitude 170°, latitude −30°; it was very dense and yellow, cutting Mare Sirenum in half. By the next night it had expanded to obscure almost all of Mare Sirenum. On September 2nd and 3rd, the yellow cloud had completely obliterated this mare, and was moving toward Thaumasia and Solis Lacus. By the 7th it had covered Solis Lacus, but the cloud was beginning to break up, and a small yellow patch just north of Aurorae Sinus could be distinctly seen. My last view of this great cloud was on September 9th, when it still obscured Mare Sirenum and parts of Solis Lacus.

This was undoubtedly the largest yellow cloud ever observed on Mars, being fully 2,000 miles long at one time, and lasting nearly two weeks. Presumably it consisted of fine dust carried high in the Martian atmosphere by winds. Fine photographs of this cloud were obtained with the 12-inch refractor of Griffith Observatory by Paul Roques, who has reported his work in the *Griffith Observer* for October, 1956.

My observations of Mars in 1956 were made with modest equipment, and required only an amount of time available to most amateurs. This account may encourage other observers to study our fascinating neighbor firsthand at its next opposition in 1958. At that time, the minimum Earth-Mars distance will be about 45.4 million miles, and the Martian disk will have an apparent diameter of more than 10 seconds of arc for about six months. Also, Mars will be considerably farther north than in 1956, being located in the constellation Taurus at its November, 1958, opposition.

LOWELL DIRECTOR RESIGNS

In January the Lowell Observatory, Flagstaff, Arizona, announced that Dr. Albert G. Wilson had resigned as director, and that Dr. Earl C. Slipher had become acting director. Dr. Wilson was made director two years ago, having formerly been on the staff of Mount Wilson and Palomar Observatories.

AMERICAN ASTRONOMERS REPORT

Here are highlights of some papers presented at the 96th meeting of the American Astronomical Society at New York City in December. Complete abstracts will appear in the Astronomical Journal.

Distant Galaxies Not Excessively Reddened

At the 78th meeting of the American Astronomical Society, in December, 1947, Joel Stebbins and A. E. Whitford, of the Washburn Observatory, reported observations with the 100-inch telescope that indicated very distant galaxies to be distinctly redder than nearby ones of similar types. This reddening was more than that expected from the red shift of the spectra of the same galaxies.

Further work was done by Dr. Whitford in 1948, also with the 100-inch telescope, on the colors of four ellipticals and seven spirals in the Corona Borealis cluster of galaxies (*Sky and Telescope*, April, 1949, page 148). While the reddening was pronounced for the ellipticals, four spirals of the most open type did not show it at all. This difference became the basis for speculations on the cause of the Stebbins-Whitford effect for the elliptical galaxies.

One interpretation involved evolutionary changes in stars. The more distant a galaxy, the longer its light takes to reach us; hence we see the members of the Corona Borealis cluster, for instance, not as they are now, but as they were several hundred million years ago. Since it was thought the red supergiant stars in an elliptical system could evolve appreciably in such an interval, it was proposed that the nearby systems are lacking in such stars and therefore do not appear as red as their distant (younger) counterparts. The ellipticals differ from the spirals in having little or no interstellar matter from which new red supergiants might be born.

Now, however, Dr. Whitford has made a new study of representative elliptical galaxies in four clusters at greatly different distances. The farthest of these clusters is receding from us at nearly one fifth the speed of light, or 60,000 kilometers per second. He has measured energy output curves photoelectrically with a seven-color filter system, from ultraviolet to infrared, using the 60-inch telescope on Mt. Wilson and the 200-inch Hale reflector. As a standard of color-energy comparison, he chose the star Spica, which has a smoother energy curve than the yellow dwarf stars used in the previous work.

After allowing for the red shift of the apparent recession, Dr. Whitford found that the energy curves for all the galaxies, near and remote, were the same within observational error. Any age effect in elliptical galaxies therefore appears to be too small to be detected by his measures.

The Wisconsin astronomer pointed out that the elliptical galaxy, M32, a companion of our great spiral neighbor, M31 in Andromeda, has an especially steep decline in its energy curve in the violet and near ultraviolet, an unknown characteristic when M32 was used as a standard in the original work on color excesses. Photoelectric scans of M32 made in 1955 by A. D. Code, of Washburn Observatory, have revealed this important fact. When proper allowance for the steep decline is made, the apparent color excess found from the 1947 two-color measurements is virtually eliminated.

The new observational result, voiding the Stebbins-Whitford effect, is consistent with the Hoyle-Schwarzschild theory of the evolution of stellar systems, which would lead to a much slower change in the magnitude and color of the brightest stars in elliptical galaxies than that expected on the 1948 hypothesis of the attrition of the red giants.

Magnitude Distribution of Visual Meteors

"A group of six observers covering the whole sky, and plotting all meteors seen, records less than five per cent of the total number visible to the naked eye." This is the conclusion reached by Peter M. Millman and Miriam S. Burland, from a study of the magnitude distribution of approximately 30,000 meteors.

These were selected from some 70,000 visual meteors that have been recorded in Canadian programs of meteor observations organized at the David Dunlap Observatory and the Dominion Observatory from 1933 to the present. The great majority of the meteors were recorded by groups of watchers working during meteor showers. On most of the programs magnitudes were estimated for all meteors seen.

Dividing the numbers of meteors observed into magnitude groups, it was found that in the absolute magnitude range −6 to 0 (very bright) the number of meteors increased by a factor of 3.7 for each magnitude interval fainter. (The absolute magnitude of a meteor is its magnitude as viewed from a distance of 100 kilometers.) Weather and observing conditions seemed to have no systematic effect on this ratio, although it tended to be smaller when computed from the data of large observing groups. The Perseid shower exhibited a larger ratio than the other showers and the nonshower meteors in general.

This ratio of 3.7 from one magnitude to the next is higher than meteor astronomers have assumed in the past; it leads to larger relative numbers for fainter meteors, but there are indications from telescopic meteor observations that the ratio may drop to 2.5 for absolute magnitude +5.

Dr. Millman is now with the National Research Council of Canada, and Miss Burland is on the staff of the Dominion Observatory, Ottawa. In closing their presentation, they pointed out that on the basis of their calculations, the earth encounters 200 million naked-eye meteors daily. These have a total mass of at least 10 tons, and possibly much more.

Changes in a Planetary Nebula

A striking progressive change in the spectrum of the small planetary nebula IC 4997 has been established by W. Liller and L. H. Aller, University of Michigan Observatory. The alteration consists of a year-to-year fading of the emission line of doubly ionized oxygen at 4363 angstroms, as compared with the hydrogen-gamma 4340-angstrom emission line. Harvard and Lick Observatory photographs in 1913-16 showed the 4363 line to be the stronger of the two; in 1938-39 it was only 30 per cent brighter than 4340; and by 1949 they were equal in intensity. Observations made last year at Mount Wilson Observatory show that the fading has continued, for the oxygen line is the weaker by 23 per cent.

This steady fading of the oxygen line is interpreted by the Michigan astronomers as due to a decrease in the number of uncombined electrons per unit volume in the planetary nebula.

Turbulence in the Sun's Atmosphere

The spectroscope can be used to detect turbulent motions of the gases in the solar atmosphere, since the random mass movements of the gas along the line of sight will broaden the dark lines in the solar spectrum. Careful measurements of the shapes of the spectral lines are necessary, and many other factors that alter line profiles must be allowed for.

The 150-foot solar tower at Mount Wilson was used by John B. Rogerson, Jr., Princeton Observatory, for measuring the profiles of 70 solar spectral lines. The 75-foot spectrograph of the tower telescope gave a spectrum with a scale of 0.3 angstrom per millimeter, which was scanned photoelectrically. Analysis of these observations suggests a turbulent velocity of 1.41 kilometers per second, which seems to be constant throughout the absorbing layers of the sun's atmosphere.

In a second paper, John H. Waddell, III, Smithsonian Astrophysical Observatory, told of his similar measurements of 11 lines, using the 52-foot vacuum spectrograph of the McMath-Hulbert Observatory (*Sky and Telescope*, July, 1955, page 372). Since his observations were

made at six positions on the solar disk at varying distances from its center, he could ascertain both the turbulent velocity parallel to the solar surface and at right angles to it. The former came out 3.0 kilometers per second, the latter 1.8 kilometers per second. It is this second value that should be compared with the 1.41 found by Mr. Rogerson, whose observations were made only for the center of the disk.

Microwave Observations of the Sun

Although at radio wave lengths as short as four millimeters the earth's atmosphere is partially opaque, useful observations can be made with small radio telescopes. At the Naval Research Laboratory, Robert J. Coates has used a 10-foot precision parabolic antenna with a beamwidth of six minutes of arc to observe the sun. The atmospheric dimming amounts to about 50 per cent for the winter noontime sun.

At four millimeters, the sun appears to be a uniform disk (when it is free of sunspots) nearly one per cent larger than its visual size. From measurements over a period of four months, beginning in July, 1956, the solar brightness temperature was found to be 7,000° Kelvin, with an uncertainty of about 10 per cent. This temperature refers to a level in the sun's atmosphere from 2,000 to 6,000 kilometers above the visible photosphere.

On October 12, 1956, a large sunspot was nearly central on the solar disk, and repeated scans at four millimeters showed it to be slightly more intense than the rest of the sun.

X-Ray Emission During Solar Flares

On July 20, 1956, a rocket fired by the Naval Research Laboratory reached an altitude of 100 kilometers only 11 minutes after a solar flare was detected at the High Altitude Observatory near Climax, Colorado. Recording instruments in the rocket indicated that even in a relatively small solar flare there is strong X-ray emission, which may be an important factor in producing some of the terrestrial S.I.D. (sudden ionospheric disturbance) phenomena associated with such outbursts on the sun.

The rocket was one of the 10 "Rockoons" launched from the U.S.S. *Colonial* in the Pacific Ocean about 200 to 400 miles southwest of San Diego, California. Each morning a helium-filled Skyhook balloon, 72 feet in diameter and carrying a 200-pound Deacon rocket, was launched and allowed to float at a height near 25 kilometers until a flare occurred, at which time the rocket was fired by radio command from the ship. Every rocket carried ionization chambers to measure Lyman-alpha radiation (at 1216 angstroms), photon counters for soft X-rays (1 to 7 angstroms), and scintillation counters for hard X-rays (0.05 to 1 angstrom).

The successful experiment was described by T. A. Chubb, H. Friedman, R. A. Kreplin, and J. E. Kupperian, Jr. They were assisted at Climax by spectroscopic observations of Richard Hansen, who on July 20th at 18:58 UT saw no flare on the sun. But between 19:05 and 19:07 a class I flare occurred, and he immediately went to the radio transmitter to inform the ship off San Diego. The rocket was released, reaching its peak altitude at 19:18:12, high enough for two minutes to measure Lyman-alpha and X-ray radiation. At 19:20 there were still signs that a flare was in progress, but shortly afterward Mr. Hansen could no longer detect flare activity on the sun.

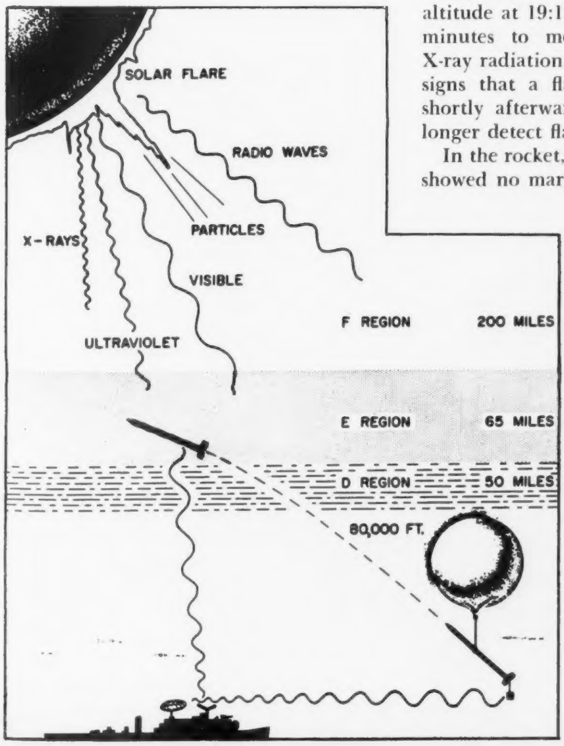
In the rocket, the Lyman-alpha detector showed no marked increase over normal, but a strong X-ray flux was recorded, penetrating the earth's atmosphere to the base of the D-layer at 70 kilometers. The intensity in the neighborhood of 3 angstroms was about 10^{-4} erg per centimeter per second. This was the first such radiation observed at so short a wave length and so low in the ionosphere.

Helium 3 in Stars?

The lightweight helium isotope of mass 3 (He^3) seems to be present in stellar atmospheres, according to E. M. and G. R. Burbidge, California Institute of Technology. Their evidence comes from spectrograms of the star 21 Aquilae taken with the McDonald Observatory 82-inch reflector, and by H. W. Babcock at Mount Wilson Observatory.

The spectrum of He^3, which has been studied in the laboratory, is very similar to that of ordinary helium of mass 4 (He^4), except for very slightly longer wave lengths for the individual spectral lines. Thus, if both He^3 and He^4 are present in 21 Aquilae, the observed lines of helium should each be a blend of the lines from the two isotopes, with a mean wave length depending on their relative proportions.

Such an effect was found by the Burbidges, who conclude that there is a reasonable probability that the helium



Left: A graphic representation of a Rockoon launching during a flare on the sun. The mother ship sends a radio signal to the rocket to release it from the balloon and fire it into the ionospheric layers, where it measures the intensity of solar ultraviolet and X-ray radiation. Naval Research Laboratory diagram.

Right: As the Skyhook rises from the deck of the ship, its bag is only partly inflated, but will expand tremendously when the balloon reaches its "cruising" altitude near 80,000 feet. U. S. Navy photograph.

In this montage of Harvard Observatory photographs, a portion of the Milky Way in Carina and Vela is at the top; the Large Magellanic Cloud is below center, and the Small Cloud is in the lower left. The overexposed image at bottom right is that of the 1st-magnitude star Achernar. The relation of the Magellanic Clouds to the Milky Way is seen here.

isotopes are about equally abundant in this star. They explain the presence of He^3 in 21 Aquilae as due to its strong and variable magnetic field, which can accelerate protons moving through its atmosphere. According to the Burbidges' suggestion, neutrons and deuterons are thereby produced, and the latter react with protons to yield the lightweight isotope.

Cygnus X Radio Sources

Using the 60-foot radio telescope of Harvard Observatory, Frank D. Drake has mapped an area of 75 square degrees surrounding the radio source known as Cygnus X. The telescope has a pencil-beam antenna pattern which is 45 minutes of arc in width between half-power points at the effective frequency used, 1,396 megacycles per second. The pointing error of the antenna was always less than one minute of arc in either co-ordinate.

The results show that Cygnus X is actually a complex of at least 11 discrete sources, all but two of which can be unambiguously identified with photographic nebulosities. The strongest source is of relatively small size, and is located very close to the star Gamma Cygni; it appears to be associated with a semicircular arc of dark material centered on the star, and with very bright emission nebulosities inside this arc.

The remaining sources are associated with hydrogen emission clouds, almost all of which are more-or-less heavily obscured by interstellar dust, but the weakest source of the complex has no observed optical counterpart.

Distortions of the Outer Regions of the Galaxy

American and Australian radio astronomers have independently discovered that the outer parts of the Milky Way galaxy are tilted with respect to the inner portion. Bernard F. Burke, Carnegie Institution of Washington, and Frank J. Kerr, J. V. Hindman, and Mrs. M. S. Carpenter, at the Radiophysics Laboratory, Sydney, carried out the closely parallel investigations.

Both studies were based on the distribution of interstellar neutral hydrogen gas, as revealed by 21-cm. observations with radio telescopes in Australia, Holland, and the United States. Most of this hydrogen is close to the galactic plane, within 30 parsecs according to Dr. Burke, but the outer hydrogen in the general direction of the Large Magellanic Cloud lies consistently below the plane by about 300 parsecs, and the anomaly is even more for the tenuous outermost edges of the system. On the other side of the galaxy, farthest from the Large Cloud, the most distant interstellar hydrogen is situated above the galactic plane by about the same amount.

In the paper from Australia, Dr. Kerr states that at a distance from the galactic center of 12,000 parsecs the maximum deviation from the principal plane is 350 to 400 parsecs, and that this is about $1\frac{1}{2}$ times the thickness of the gas layer.

This systematic tilt has the appearance of a tidal deformation of the Milky Way galaxy by the attraction of the Large Magellanic Cloud. Both the American and Australian investigators find, however, that the distortion is considerably greater than would arise from gravitational forces only. There may be an analogy with the cases (discussed by Otto Struve in the February issue) of unexpectedly large interactions between adjacent galaxies.

DUST ON THE MOON

The lunar maria are probably low-lying regions covered with dust slowly being eroded from the moon's highlands, according to Thomas Gold, Royal Greenwich Observatory (now at Harvard). While the proposal of erosion on the moon is not novel, many new ideas are developed by him on the physical processes involved.

If the maria are dust plains, it is no longer necessary to suppose that there have been lava flows on the moon. No large-scale melting of our satellite during its history need then be postulated, and the moon may have been a relatively cold body throughout its evolution.

Professor Gold outlines his proposals in the *Monthly Notices* of the Royal Astronomical Society, *115*, 585, in a comprehensive article on many phases of the lunar problem. For instance, he examines in detail the phenomena accompanying the impact of a large meteorite, predicting the formation of central peaks in impact craters and, in some cases, the production of small craterlets on these peaks.

Observational evidence for lunar erosion is afforded by overlapping craters, the one with an unbroken rim presumably being the younger. According to Professor Gold, its rim is sharper and less weathered than the walls of the older crater. In the absence of an appreciable atmosphere on the moon, the weathering would be due mainly to meteoritic bombardment over long periods. This would produce dust, which would be augmented by the destruction of surface crystalline material by the sun's ultraviolet light and X-rays. Micrometeorites would also add to the dust accumulation.

Several physical processes should enable the dust from the lunar highlands to flow slowly over the moon's surface and to accumulate in low areas. Among these agencies are agitation by micrometeorite impacts, electrostatic effects, and evaporation-condensation cycles. The darker color of the maria may be produced by chemical action or X-rays; recently eroded parts of the crater wall and mountainous regions would show the light shade of the moon's underlying material.

Amateur Astronomers

Monte Sano Observatory Completed in Alabama

ROCKET CITY Astronomical Association members began work on their observatory in April last year. The building has now been practically completed, with a cash outlay of only $3,000, and most of this was contributed by business firms and interested individuals in Huntsville, Alabama, and vicinity.

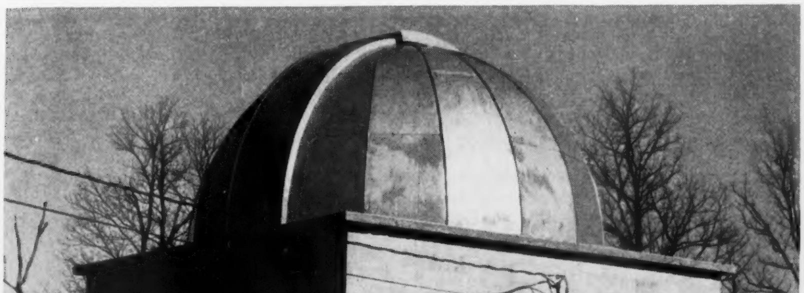
Donations by founders of the society had made possible the purchase, in the spring of 1955, of a 16½-inch reflector which formerly served as an auxiliary instrument at the Palomar Observatory. It is being used as a Newtonian, with a temporary clock drive built by Dr. Ernst Stuhlinger; a Cassegrainian secondary may be added later.

The observatory is located in Monte Sano state park on a 13½-acre site that has been rented for a nominal fee from the state; the 25-year lease is renewable at the option of the association. The reinforced steel and concrete ring supporting the dome measures 24 feet square outside and has an inside diameter of 18 feet.

The society has more than 100 members, three fourths of them employed at the Army Ballistic Missile Agency and at the neighboring Redstone Arsenal. Others are teen-age and adult amateur astronomers living in the Huntsville area. The members took part in clearing the land, procuring county aid in the construction of a road, and building the observatory. One member, hotel manager Quincy B. Love, installed the plumbing and himself poured several thousand pounds of concrete; he also supervised construction of the building, which was designed by Wilhelm Angele.

Wednesday evenings were set aside for work on the project, Saturdays for observing. Junior members of the group helped lay the brickwork and blocks and did other chores.

The leaders of the society, including its president, Dr. Wernher von Braun, are experts in rocketry and space-travel studies. In the near future they plan to publish a new magazine, *Space Journal*, to which well-known rocket men are expected to contribute. The editor-in-chief will be B. Spencer Isbell, vice-president of the association.



Dr. Wernher von Braun, space-travel authority, stands at the entrance to the new Monte Sano Observatory, near Huntsville, Alabama.

DES MOINES, IOWA

The Great Plains Astronomical Society will hold its general convention on March 17th in Des Moines, Iowa, at the Drake University Municipal Observatory. The meeting will begin at 2 p.m. in the lecture hall. A filmstrip and discussion on the artificial satellite will be the main features of the program.

NORTHEAST IOWA

The Northeast Iowa Division of the Great Plains Astronomical Society has been organized. The club meets at various places within its territory. Further information about the group may be obtained from Charles P. Martens, R.F.D. 4, Charles City, Iowa.

EAST CLEVELAND, OHIO

A series of open nights for the public is being held at the Warner and Swasey Observatory, Taylor Rd., East Cleveland, Ohio. The lectures begin at 8 p.m.

The topic for March 7th and 8th will be "An Observatory at the Moon"; for April 4th and 5th, "Artificial Satellite"; and for May 2nd and 3rd, "Surveying the Universe with Radio Telescopes."

For reservations, call the Warner and Swasey Observatory, GLenville 1-5625, between 1 and 5 p.m.

THIS MONTH'S MEETINGS

Cleveland, Ohio: Cleveland Astronomical Society, 8 p.m., Warner and Swasey Observatory. Mar. 15, Dr. Cedric Hesthal, Ohio State University, "Physical Concepts."

Dallas, Tex.: Texas Astronomical Society, 8 p.m., Lone Star Gas Co. auditorium. Mar. 25, E. M. Brewer, "A Trip Through Space."

Geneva, Ill.: Fox Valley Astronomical Society, 8 p.m., City Hall. Mar. 19, symposium on "Aspects of Time."

Louisville, Ky.: Louisville Astronomical Society, 8:30 p.m., University of Louisville, Natural Science building. Mar. 5, panel discussion on "The Origin of the Universe."

Madison, Wisc.: Madison Astronomical Society, 8 p.m., Washburn Observatory. Mar. 13, Prof. Farrington Daniels, University of Wisconsin, "Capturing Heat from the Sun."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. Mar. 6, Lorits C. Eichner, L. C. Eichner Instruments, "Astronomical Instruments of the 16th Century."

Santa Ana, Calif.: Orange County Amateur Astronomers, 7:30 p.m., home of R. E. Ferguson, 18175 Pemberco Circle, Huntington Beach. Mar. 1, Norman Jarvi, "Star Chemistry with the Spectroscope."

Springfield, N. J.: Amateur Astronomical Society of Union County, 8 p.m., Regional High School. Mar. 22, Keith H. Storks, Bell Laboratories, "Spectroscopy in the Analysis of Materials."

ASTRONOMICAL LEAGUE CONTEST FOR JUNIORS

All junior members of societies and of junior groups belonging to the Astronomical League are eligible to enter a contest that runs through May. Each contestant should write a story on some astronomical subject, excluding space travel, its length about four pages (eight minutes reading time).

First prize is a Spitz Moonscope; second, a slide or chart set from Astronomy Charted; and third, *The Stars: A New Way to See Them*, which will be autographed by the book's author, H. A. Rey. All entries should be mailed to

Clarence E. Johnson, 102 State St., Schenectady, N. Y., before June 3rd. The winners will be announced at the junior program of the Kansas City convention of the league on September 1st, but winners need not be present at the convention.

A GARAGE-TOP OBSERVATORY

Located on the corner of a heavily traveled street about four miles from the Griffith Planetarium, our observatory creates quite an amount of public interest in our neighborhood. As the picture shows, it is supported by both the garage and the ground, and is reached by a flight of steps.

The observatory building is 16 feet high, eight feet square, with plywood walls about six feet high. The aluminum dome, 7½ feet in diameter, revolves on roller bearings on a circular track, but can be anchored to the main part of the observatory for protection against wind and storms. The observing slit is 18 inches wide, extending two thirds of the way over the top of the dome.

The tripod that holds our 4-inch Unitron refractor has been anchored to the floor to prevent accidental tipping. At the near corner of the observatory, the picture shows an overhead carrier that is connected by a cable wire to our home: this is used for transporting coffee and midnight snacks.

C. STUART STEELMAN
123 South Brand Blvd.
Glendale 4, Calif.

The Steelman observatory atop a garage in Glendale, California.

Planetarium Notes

(Most planetariums give group and special showings by appointment.)

BALTIMORE: *Davis Planetarium.* Maryland Academy of Sciences, Enoch Pratt Library Building, 400 Cathedral St., Baltimore 1, Md., Mulberry 2370.
SCHEDULE: Monday (Sept.-June), 3:45 p.m.; Thursday, 7:15, 7:45, 9 p.m. Admission free. Spitz projector. Director, Paul S. Watson.

BLOOMFIELD HILLS, MICH.: *McMath Planetarium.* Cranbrook Institute of Science, Bloomfield Hills, Mich.
SCHEDULE: Saturday and Sunday, 2:30 and 3:30 p.m. Spitz projector. In charge, James Carmel.

BUFFALO: *Buffalo Museum of Science Planetarium.* Humboldt Parkway, Buffalo, N. Y., GR-4100.
SCHEDULE: Sunday, 2 to 4:30 p.m. (except summer). Admission free. Spitz projector. Director, Fred Hall.

CHAPEL HILL: *Morehead Planetarium.* University of North Carolina, Chapel Hill, N. C.
SCHEDULE: Daily, 8:30 p.m.; also at 11 a.m. and 3 p.m. Saturday, 3 and 4 p.m. Sunday. Zeiss projector. Manager, A. F. Jenzano.

CHARLESTON, W. VA.: *Hillis Townsend Planetarium.* Children's Museum, Public Library Building, Charleston, W. Va.
SCHEDULE: Saturday, 11 a.m. Admission free. Spitz projector. Director, Mrs. R. L. Sullivan.

CHICAGO: *Adler Planetarium.* 900 E. Achsah Bond Drive, Chicago 5, Ill., Wabash 2-1428.
SCHEDULE: Monday through Saturday, 11 a.m. and 3 p.m.; Tuesday and Friday, 8 p.m.; Sunday, 2 and 3:30 p.m. Zeiss projector. Director, Wagner Schlesinger.

DALLAS: *Dallas Planetarium.* Dallas Health Museum, Fair Park, Dallas 10, Tex., HA 8-5755.
SCHEDULE: Saturday, 11 a.m.; Sunday, 2:30 and 4:30 p.m. Spitz projector. Director, Mrs. Claudia Robinson.

DENVER: *Denver Museum of Natural History Planetarium.* City Park, Denver, Colo., East 2-1808.
SCHEDULE: Saturday and Sunday, 1 to 4:30 p.m. Spitz projector.

FT. WORTH: *Charlie M. Noble Planetarium.* Ft. Worth Children's Museum, 1501 Montgomery St., Ft. Worth, Tex., PA-1461.
SCHEDULE: Tuesday through Saturday, 11 a.m., 1:30 and 2:30 p.m.; Sunday, 2:30 p.m. Spitz projector. Director, William Hassler.

INDIANAPOLIS: *Holcomb Planetarium.* Butler University, Indianapolis 7, Ind.
SCHEDULE: Saturday and Sunday, 4 and 8 p.m. Spitz projector. Director, Harry E. Crull.

KANSAS CITY: *Kansas City Museum Planetarium.* 3218 Gladstone Blvd., Kansas City 23, Mo., Humboldt 3-8000.
SCHEDULE: Saturday and Sunday (except first weekend of month), 3 p.m. Spitz projector. Director, Kenneth W. Prescott.

LANCASTER, PA.: *North Museum and Planetarium.* Franklin and Marshall College, Lancaster, Pa.
SCHEDULE: Tuesday and Thursday, 8 p.m.; Saturday and Sunday, 3 p.m. Admission free. Spitz projector. Curator, John W. Price.

LAQUEY, MO.: *Tarbell Planetarium.* Inca Cave Park, Laquey, Mo.
SCHEDULE: Alternate Sundays, 1 to 6 p.m., continuous. Spitz projector. Director, E. D. Tarbell.

LOS ANGELES: *Griffith Observatory and Planetarium.* Griffith Park, P. O. Box 27787, Los Feliz Station, Los Angeles 27, Calif., Normandy 4-1191.
SCHEDULE: Daily (except Monday and Tuesday), 8:30 p.m.; also 3 p.m. Saturday and 3 and 4:15 p.m. Sunday. Zeiss projector. Director, Dinsmore Alter.

MINNEAPOLIS: *Science Museum.* Minneapolis Public Library, 1001 Hennepin Ave., Minneapolis 3, Minn.
SCHEDULE: Saturday, 10 a.m. and 2 p.m. Admission free. Spitz projector. Curator of education, Maxine B. Haarstick.

NASHVILLE: *Sudekum Planetarium.* Children's Museum, 724 2nd Ave. S., Nashville 10, Tenn., 42-1858.
SCHEDULE: Sunday, 2:45, 3:30, 4:15 p.m. Spitz projector. Assistant curator of education, Donald Davis.

NEWARK: *Newark Museum Planetarium.* 49 Washington St., Newark 1, N. J., Mitchell 2-0011.
SCHEDULE: Saturday, Sunday, and holidays, 2:30 and 3:30 p.m. Admission free. Spitz projector. In charge, Ray Stein.

NEW YORK CITY: *American Museum-Hayden Planetarium.* 81st St. and Central Park West, New York 24, N. Y., Trafalgar 3-1300.
SCHEDULE: Monday through Friday, 2, 3:30, and 8:30 p.m.; Saturday, 11 a.m., 1, 2, 3, 4, 5, and 8:30 p.m.; Sunday and holidays, 1, 2, 3, 4, 5, and 8:30 p.m. Zeiss projector. Chairman, J. M. Chamberlain.

PHILADELPHIA: *Fels Planetarium.* Franklin Institute, 20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Locust 4-3600.
SCHEDULE: Tuesday through Sunday, 3 p.m.; Saturday, 11 a.m.; Saturday, Sunday, and holidays, 2 p.m.; Wednesday, Friday, and Saturday, 8:30 p.m. Zeiss projector. Director, I. M. Levitt.

PITTSBURGH: *Buhl Planetarium and Institute of Popular Science.* Federal and West Ohio Sts., Pittsburgh 12, Pa., Fairfax 1-4300.
SCHEDULE: Monday through Saturday, 2:15 and 8:30 p.m.; Sunday, 2:15, 4:15 and 8:30 p.m. Zeiss projector. Director, Arthur L. Draper.

PORTLAND, ORE.: *Oregon Museum of Science and Industry Planetarium.* 908 N.E. Hassalo St., Portland 12, Ore., East 3807.
SCHEDULE: Saturday and Sunday, 3 p.m. Spitz projector.

PROVIDENCE: *Roger Williams Planetarium.* Roger Williams Park Museum, Providence 5, R. I., Williams 1-5640.
SCHEDULE: Saturday, Sunday, and holidays, 3 and 4 p.m. (Oct.-June). Admission free. Spitz projector. Director, Maribelle Cormack.

SAN FRANCISCO: *Morrison Planetarium.* California Academy of Sciences, Golden Gate Park, San Francisco 18, Calif., Bayview 1-5100.
SCHEDULE: Daily (except Monday and Tuesday), 3:30 and 8:30 p.m.; also 2 p.m. Saturday, Sunday, and holidays. Academy projector. Curator, George W. Bunton.

SAN JOSE, CALIF.: *Rosicrucian Planetarium and Science Museum.* Park Ave. and Naglee Ave., San Jose, Calif.
SCHEDULE: Sunday and Wednesday, 2 and 3:30 p.m. Spitz projector. Director, Rodman R. Clayson.

SPRINGFIELD, MASS.: *Seymour Planetarium.* Museum of Natural History, Springfield 5, Mass.
SCHEDULE: Tuesday, Thursday, and Saturday, 3 p.m.; also 8:30 p.m. Tuesday; special star stories for children, Saturday, 2 p.m. Admission free. Korkosz projector. Director, F. Korkosz.

BOOKS AND THE SKY

ASTRONOMICAL OPTICS AND RELATED SUBJECTS

Zdenek Kopal, editor. Interscience Publishers, Inc. New York, 1956. 428 pages. $12.50.

IN APRIL, 1955, a symposium on astronomical optics and related subjects was held at the University of Manchester under the auspices of its astronomy department. Approximately 60 papers were presented, most of which are reprinted in this book.

A remarkable range of topics is covered, such as image-formation interferometry, filter photography, photoelectric light detectors, and image tubes. The first five contributions deal with mutual aspects of optics and information theory. Ten papers are devoted to optical images and diffraction. This group also covers the theory of the phase-contrast microscope, antenna designs for radio astronomy and their particular properties, and apodizing screens made to reduce the intensity of diffraction rings and halos around images.

A very complete survey of photoelectric aids in astronomy is offered. McGee discusses photomultipliers and image converters, also reviewing some astronomical applications of television techniques. He treats pickup tubes such as the Image-Orthicon and the CPS Emitron, and discusses a tube he previously proposed for image storage over several hours. Fellget supplies a study of the use of television techniques, and reports on actual trials of pickup tubes.

Subsequent papers describe photoelectric spectrophotometers. The importance of electronic digital computers for ray-tracing and optical design problems and the application of image-storage devices to the presentation of optical diffraction patterns are stressed. This chapter, and the concluding one on filter photography and thin films, reveal fields where the most promising progress in observational methods has recently been made.

Fabry-Pérot interferometers and interference filters are evaluated by several authors. This reviewer feels that a report on Harrison's work at Massachusetts Institute of Technology on spectroscopy with the echelle—a promising technique for astronomical research—would have been a valuable addition to the symposium. Kopal and Millns talk about dye filters of small band-width for wide-angle cameras. A long series of papers deals with resolution problems and scintillation; another paper is devoted to wide-angle optical systems and aspherical surfaces.

The generation of aspherical surfaces of high accuracy offers many difficulties. Weinstein and Dobrowolski propose a method to produce such surfaces, not by high-grade grinding and polishing but by evaporation and deposition of suitable materials in vacuum, a process requiring less skilled labor. Bigay describes the design of a spectrograph employing aspherical mirror optics with a very fast system. Fehrenbach gives a resume of his method for measuring radial velocities with the aid of an objective prism.

The publisher has not failed to incorporate a large number of interesting photographs and diagrams, many of them not available elsewhere. However, in view of the price of the volume, the binding is somewhat unsatisfactory.

G. R. MICZAIKA
Harvard College Observatory

ROCKETS AND GUIDED MISSILES
John Humphries. The Macmillan Co., New York, 1956. 229 pages. $6.00.

THREE ASPECTS of this book recommend it. First, it is written by a competent rocket engineer, who not only knows his subject but is able to present his knowledge clearly and concisely. Second, *Rockets and Guided Missiles* is of sufficiently high technical level to separate it from the profusion of general rehashes that have appeared in the past few years. Yet its essentially nonmathematical approach makes it valuable to a wide audience, from the informed layman to the practicing engineer. Third, a wealth of material has been assembled in a logically organized fashion, much of which has appeared previously only in widely scattered technical reports and in scientific journals.

The book is well illustrated and contains many valuable tables, charts, and graphs. It is largely free from the almost inevitable errors that creep into this type of book, although a few do occur. For instance, the MX-774 reached 30 miles plus, not 100 miles plus, and the United States height record of a V-2 was 132 miles, not 114.

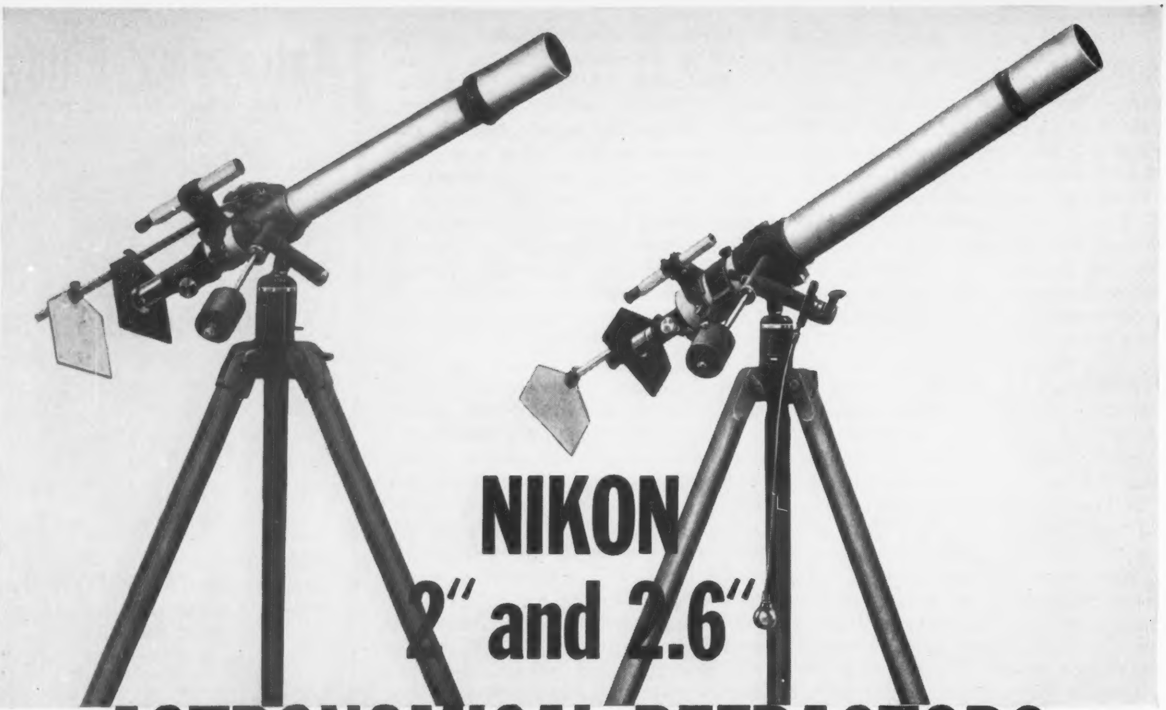
An inspection of nearly 20 pages of references shows that the author has gone into his subject thoroughly. While some reports may not be readily available in this country, this bibliography should be of much aid to the student of rocketry and missiles.

The author mentions in the foreword that he has drawn heavily from German World War II sources. This excellent information includes some illustrations of German missiles that have not appeared in other books, as far as this reviewer knows. Oddly, the book contains little up-to-date material on the large crop of American, British, French, and other postwar rockets that a work bearing a 1956 publication date should include. The value of the book might have been enhanced by the introduction of the Redstone, Atlas, Jupiter, Falcon, Navaho, Dart, Deacon, Asp, and other current missiles, although the author tells us it is not meant to be a comprehensive source book.

After a more-or-less standard history of rocketry, separate chapters are offered on solid-propellant rocket motors, liquid-propellant rocket motors, liquid rocket components, units, and testing devices and techniques. Other material includes missile aerodynamics, guidance, short-range aerodynamic and long-range ballistic missiles, propulsion systems, rocket aircraft, research missiles, testing, miscellaneous applications of rocket power, nuclear energy for rocket propulsion, and space flight.

For the most part, *Rockets and Guided Missiles* gives a down-to-earth and practical treatment of its subject. Several terms common in Great Britain, where the book was written, should not trouble American readers. It is hoped that the author will soon prepare a second edition tying the principles he knows so well to the latest information on both research and military rockets and missiles.

FREDERICK I. ORDWAY, III
General Astronautics Corp.



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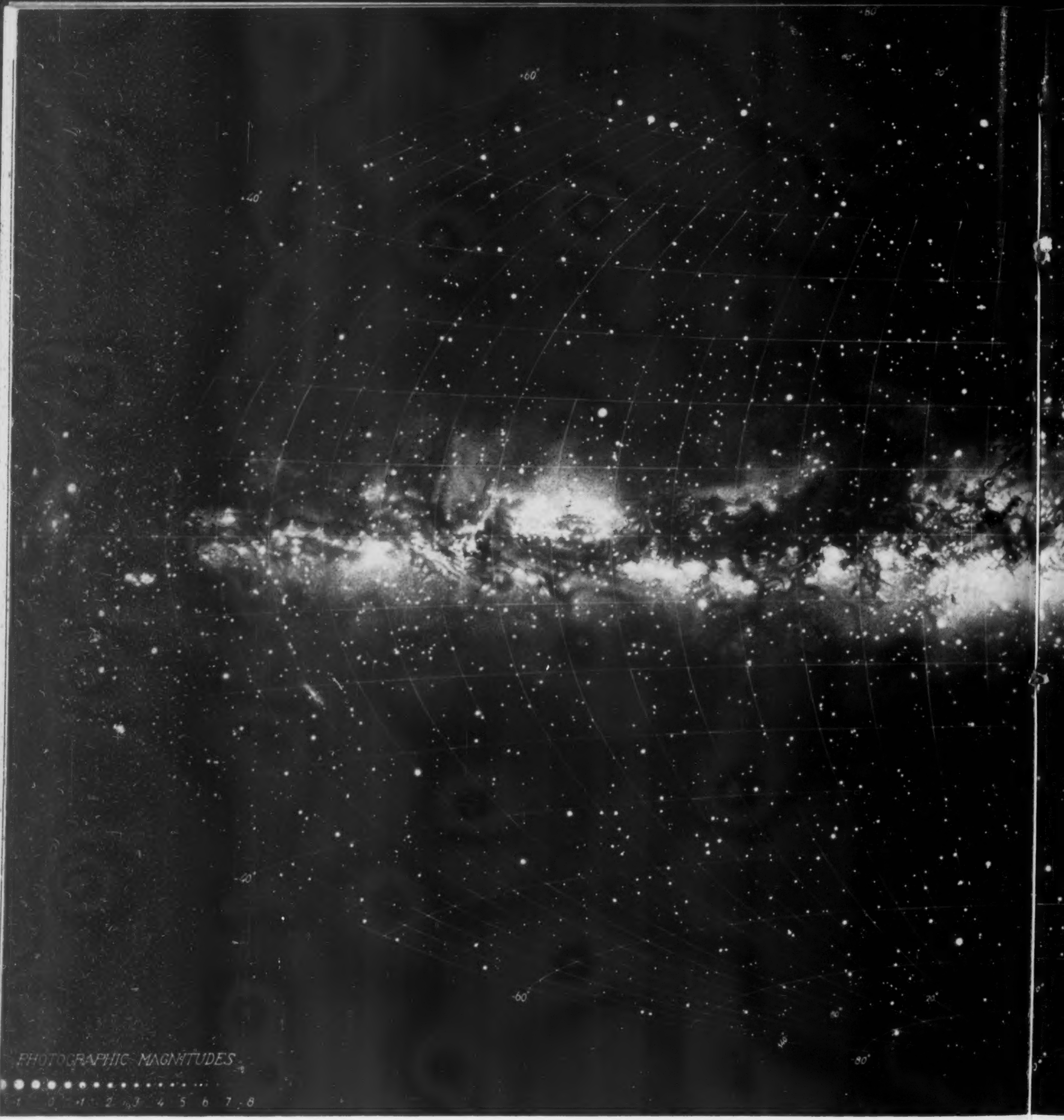

A Swedish Chart of the Ph

THE INTRICATE and beautiful structure of the Milky Way portrayed on photographs is displayed in this drawing made in Sweden by Martin Kesküla and his wife Tatjana. Working at the Lund Observatory under the writer's direction, they required four years to complete the chart, which is reproduced here slightly less than one fifth its original size of 7½ by 4 feet.

The course of the Milky Way around the entire sky is shown, beginning with Auriga and Perseus at the left, extending through the bright regions of Cassiopeia and Cepheus, and with the great dark rift in Cygnus and Aquila conspicuous to the left of center. In the middle is Sagittarius, and the direction of the galactic center; farther to the right is the southern Milky Way, passing through Centaurus, Crux, Puppis, and Canis Major. It continues more faintly through Monoceros and Gemini to Auriga once more.

In the lower right, the bright patches that look like detached fragments of the Milky Way are the Small and Large

e Photographic Milky Way

Magellanic Clouds, our neighbor galaxies.

In this equal-area Aitoff projection, the distortion of distances is least at low latitudes—the Milky Way is very nearly proportioned as it appears in the sky. The grid lines indicate galactic latitudes and longitudes, at intervals of 10 degrees. Some 7,000 of the photographically brightest stars in the sky were plotted by Mr. Kesküla.

Structural details of the Milky Way were drawn in white India ink on the dark tempera background, following the photographic atlases of the American astronomers Solon I. Bailey and Frank E. Ross. For relative brightnesses of the different features, we used the contour lines of equal brightness determined by the Netherlands astronomer Antonie Pannekoek.

Much labor has been spent, not only to obtain an esthetically pleasing picture of the Milky Way but to give an accurate representation of the star clouds, clusters, and bright and dark nebulosities.

KNUT LUNDMARK, director
Lund Observatory, Lund, Sweden

HOW TO MAKE AND USE A TELESCOPE

H. Percy Wilkins and **Patrick Moore.** W. W. Norton and Co., Inc., New York, 1956. 196 pages. $2.95.

THE TITLE of this book is somewhat misleading as it covers many subjects other than just the telescope, and it does not give all the information necessary for one to make his own telescope. It does, however, take much of the mystery away from the grinding and figuring of mirrors, so the novice will know better what he is attempting if he makes his own reflector.

The authors emphasize the need for great patience in progress toward the finished product, a telescope that will be useful in the hands of the average observer. But they are brief in their instructions, and devote more space to the history of the telescope and to introductory material on other astronomical devices, such as the micrometer and the thermocouple. Most amateurs have thought that the two foregoing instruments are beyond their reach, but this book points out that such gadgets can be fascinating tools for the amateur.

Although they are principally observers of the moon, the writers of this book describe methods of observing the planets, the sun, and other stars, as well as the average run of special objects the serious amateur might study. The usual precautions in viewing the sun are mentioned several times, and the history of instruments used in the study of our nearest star is given a prominent place.

Some good advice is given to the photographer. He is cautioned to use those powers of magnification that will produce an image that is clear and sharp rather than one which is larger. Careful notes when taking a series of pictures will help in establishing best focus, and in other ways will soon enable the tyro to become an expert in celestial photography.

An observatory is unnecessary—one of the authors has had his 15¼-inch reflector in the open for years with no damage to it whatsoever. But several methods of observatory construction are given, and emphasis is placed on the quality of workmanship rather than on speed. One gathers that the ownership of back-yard instruments is more common in England than here and that possibly a permanent mounting is a thing to be expected. In America, on the other hand, it is most important that the average amateur can throw the family telescope in the car and make for spots of better seeing.

Some acquaintance of the reviewer with Dr. Wilkins on his visit here in 1954 has added to the pleasure of reading this book. Probably few men have his knowledge of the moon, yet he and his coauthor emphasize the need to learn as much of all branches of astronomy as

possible. They recommend especially that amateurs form groups and clubs if they wish to enjoy their hobby to the fullest.

In this volume, however, the authors have missed the chance to say a few words to those of more tender years, say juniors from the ages of 7 and up. While the book covers a lot of territory, it omits this great field. Someday someone will emphasize the need for astronomy and other science studies to begin seriously in the lower grades, instead of waiting for young people to take up science later.

CLARENCE E. JOHNSON
Junior Activities chairman
Astronomical League

DIE MONDFINSTERNISSE

Frantisek Link, Akademische Verlagsgesellschaft, Sternwartenstrasse 8, Leipzig C1, East Germany, 1956. 127 pages. DM 15.

EVEN THOUGH eclipses of the moon have been familiar phenomena since the dawn of history, Dr. Link's book is probably the first to be entirely devoted to them. His bibliography of 192 references does not list any predecessor.

As this fact suggests, recent years have seen a revived interest in lunar eclipses. Their new importance is as a tool for investigating the earth's atmosphere. During an eclipse, sunlight is refracted into the earth's umbra or shadow. Suitable observations of the moon, as it traverses the shadow, allow us to map the pattern of light within the umbra. From this, important conclusions can be drawn concerning our upper atmosphere. For example, one way to determine the height of the atmospheric ozone layer is by spectrographic observations of the eclipsed moon.

Eclipses of the Moon is therefore largely devoted to photometric problems, on which the author and his collaborators in Czechoslovakia have been working for over two decades. Using modern data on the earth's upper atmosphere, he presents a detailed theory of the distribution of light of various wave lengths inside the umbra. Comparing his predictions with eclipse observations, Link finds that the central parts of the shadow are denser than expected—as earlier investigators had noted with less certainty. He attributes this effect to an absorbing layer in the upper atmosphere, which he believes due to meteoritic particles.

The obscured moon varies widely in brightness from one eclipse to another. Years ago A. Danjon pointed out that these changes seem related to solar activity; near sunspot minimum, eclipses tend to be very dark, but grow brighter and brighter as the solar cycle proceeds, until at the next minimum dark eclipses set in once more. The evidence for this

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was vigorously rebutted by E. W. Maunder and by W. J. Fisher, and the idea fell into astronomical disfavor. Now, Link shows serious weaknesses in their criticisms; the whole problem is reopened, and a deeper examination is in order.

Link's recommendations to observers of future lunar eclipses are important, because of his long experience. The greatest need is for photometric studies of eclipses, to determine the brightness inside the shadow. If they are to have value, however, such observations must be made with filters isolating rather narrow wavelength bands. For amateur astronomers, Link urges the timing of passages of individual craters through the edge of the umbra, observations that can easily be made with small telescopes. (See February issue, page 196.) Their scientific value is greater than had been realized a few years ago, Link points out.

While this monograph is written primarily for specialists, amateur astronomers who read German will find much of interest, notably in chapter 9, on observing problems and methods.

JOSEPH ASHBROOK

NEW BOOKS RECEIVED

THE SUN, *Giorgio Abetti*, 1957, *Macmillan*. 336 pages. $12.00.

Long recognized as a standard treatment of its topic, *The Sun* has now been translated from the Italian by J. B. Sidgwick, based on the 1954 enlarged and revised third edition. It is a comprehensive summary of all aspects of modern solar knowledge.

TEACHING ASTRONOMY IN SCHOOLS, *Ernest Agar Beet*, 1956, *Cambridge University Press*, New York. 72 pages. $1.50.

While intended for guidance of teachers in British schools, this book contains many suggestions that should prove useful to educators elsewhere who would like to include some astronomy on an elementary- or high-school level. Topics covered include syllabuses, equipment, classroom and outdoor work, books, maps, films, and telescopes.

THE HANDBOOK OF THE BRITISH ASTRONOMICAL ASSOCIATION 1957, *J. G. Porter*, editor, 1956, *British Astronomical Association*, 303 Bath Rd., Hounslow West, Middlesex, England. 64 pages. 3s for members; 5s for nonmembers; paper bound.

Every serious observer will find the BAA *Handbook* an invaluable aid. It contains ephemerides of the sun, moon, planets, and of the periodic comets expected to return this year. There are predictions of phenomena of Jupiter's satellites, and data for identifying the moons of Saturn. A very useful feature for the amateur is the set of finding charts for Uranus, Neptune, and Pluto.

THE MILKY WAY, *Bart J. Bok* and *Priscilla F. Bok*, 1957, *Harvard University Press*. 269 pages. $5.50.

A completely rewritten third edition of *The Milky Way*, one of Harvard Observatory's noted books on astronomy, has been prepared by the new director of the Australian Commonwealth Observatory and his wife.

THE STARS: STEPPINGSTONES INTO SPACE, *Irving Adler*, 1956, *John Day*. 128 pages. $2.95.

This book, illustrated by Ruth Adler, is an introduction to the mysteries of the heavens for the young reader. It tells the main conclusions that astronomers have now reached about the stars, and explains the evidence that led to these conclusions.

SOLAR ECLIPSES AND THE IONOSPHERE, *W. J. G. Beynon* and *G. M. Brown*, editors, 1956, *Pergamon*. 330 pages. $21.00.

The ionized layers of the earth's upper atmosphere and the changes they undergo when the sun is eclipsed form the subject of this book, which reports the London symposium of August, 1955. Six of the papers deal with solar radio noise. A timely chapter by Mrs. S. D. Gossner points out the unusual properties of the Antarctic eclipse of October 23, 1957; the axis of the umbra will miss the earth's surface by only 33 kilometers, making the eclipse central in the ionosphere but partial on the ground. There is an exhaustive bibliography of ionospheric observations at solar eclipses from 1912 to 1954.

ARIZONA'S METEORITE CRATER, *H. H. Nininger*, 1956, *American Meteorite Museum*, Sedona, Ariz. 232 pages. $3.75.

An expert on meteorites summarizes what is known about the great meteorite crater in north central Arizona, in a book intended for both the general reader and the specialist.

THE AIRGLOW AND THE AURORAE, *E. B. Armstrong* and *A. Dalgarno*, editors, 1956, *Pergamon*. 420 pages. $22.50.

This volume consists of 54 papers presented at an international conference on the light of the night sky, held at Belfast, Ireland, on September 6-7, 1955. The topics include photometry and spectroscopy of the airglow, the gegenschein, persistent meteor trains, observations and theoretical studies of the aurora, and instruments for airglow and auroral observations. The book is especially of interest to research workers who will be engaged in these fields during the International Geophysical Year.

ATOMS AND THE UNIVERSE, *G. O. Jones*, *J. Rotblat*, and *G. J. Whitrow*, 1956, *Scribner's*. 254 pages. $4.50.

Three scientists tell in popular language how modern physics has given new insight into the structure of matter and of the universe.

NEW HORIZONS IN ASTRONOMY, *Fred L. Whipple*, editor, 1956, *U. S. Government Printing Office*, Washington 25, D. C. 181 pages. $1.50, paper bound.

This is Volume 1, Number 1 of the Smithsonian Contributions to Astrophysics, a new series which will report the results of research conducted at the Smithsonian Astrophysical Observatory. In this number more than three dozen astronomers and geophysicists present brief summaries of their fields.

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CONDUCTED BY ROBERT E. COX

A Cassegrainian-Maksutov Telescope Design for the Amateur

TELESCOPE MAKERS who take the extra effort to construct a two-element Maksutov can then enjoy many gratifying hours of fine observing. The writer has built a 5-inch instrument of this type that for convenience, ease of transporting and observing, far outclasses the old-fashioned reflector or refractor. My own 4-inch refractor is now in moth balls.

And although you may have heard that a Maksutov is a catadioptric system requiring special design, costing upwards of a thousand dollars when commercially made, there is no question that if you are an average ATM you can fabricate the parts yourself. Furthermore, because of the short tube length you will have no trouble providing an equatorial mounting. My 5-inch has an effective focal length of 100 inches, quite suitable for planetary work, yet its tube is only about a foot and a half long.

The Maksutov and other popular catadioptric systems were described by Earle B. Brown in this department in September, 1956 (page 511). D. D. Maksutov in 1944 published the basic formulas and introduced various forms of the system now named after him. The Perkin-Elmer Corp. has recently fabricated triple-element Cassegrainian-Maksutov instruments designed by James G. Baker to provide a high degree of correction for coma and astigmatism.

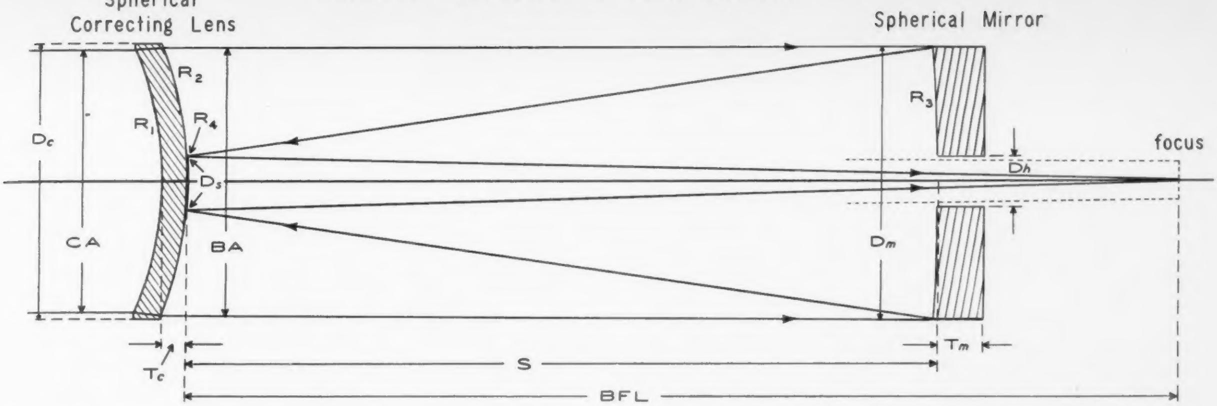
However, for visual use and small-field photography (half a degree), the two-element design I have used makes a fine telescope with several advantages over refractors and reflectors of equal aperture. There is no secondary spider support to introduce undesirable diffraction, and no color fringes (secondary spectrum) that reduce image contrast. The completely closed tube does away with thermal effects, which may seriously impair resolution when an open-tubed reflector is taken from a cellar or garage into the cool night air.

Design. The Cassegrainian-Maksutov may be thought of as evolving from the Dall-Kirkham reflector, which uses a spherical convex secondary and a concave primary of 60- to 80-per-cent parabolization. Now visualize a disk or shell cut from a soap bubble of the same curvature as the secondary, with an aluminized spot in the center of the disk. This disk can be placed in the position of the Dall-Kirkham secondary without changing the optical characteristics of the system, as the very thin bubble shell will have no effect on the incident light.

But we would prefer the primary mirror to be spherical, for convenience and accuracy in figuring and testing. And, even if the shell were made of glass, it would be too thin to grind and polish.

John Gregory at the eyepiece of his 5-inch Maksutov telescope, which was awarded first prize for optical excellence at the Stellafane meeting at Springfield, Vermont, in August, 1956 (see October issue). The primary mirror is perforated to allow observation at the Cassegrainian focus, where a zenith prism has been added for convenience in observing. Photograph by George Bakes.

MAKSUTOV TELESCOPE BY JOHN GREGORY



The shell must be made thick so it becomes self-supporting, whence it acts like a lens, introducing negative spherical aberration to the light passing through it on the way to the primary. Yet this effect is favorable, for it allows us to reduce the parabolization of the primary; in fact, we can make the primary mirror spherical.

Obviously, the thickness of the shell should then be such that its negative spherical aberration, combined with that of the secondary mirror (aluminized spot), balances the positive aberration of a spherical primary mirror. In practice, to minimize chromatic aberration of the lens, its two surfaces have slightly different radii. The formula for the axial thickness, t, that will reduce chromatic differences to an insignificant amount is

$$\mathbf{t} = (\mathbf{R}_2 - \mathbf{R}_1)\,\mathbf{n}^2/(\mathbf{n}^2 - 1),$$

where **n** is the index of refraction, $\mathbf{R}_1$ the radius of curvature of the front surface of the corrector lens, and $\mathbf{R}_2$ the radius of the back surface, which bears the secondary mirror spot.

Maksutov has given a very complete table of designs for the simple shell plus primary mirror, but no curves for a compound system, so I applied the principle embodied in the formula above to set up two designs. The equivalent focal lengths, separations, and mirror radii should check with the conventional Cassegrainian formula given on page 63 of *Amateur Telescope Making.*

Both designs are for a Maksutov correcting lens of 6-inch clear aperture, one with an equivalent focal length (EFL) of 140 inches, the other of 90 inches. At f/23, the first is intended primarily as a planetary-observing instrument, giving adequate magnification with a comfortable ½-inch eyepiece. The other, at f/15, is more versatile—a wide field may be viewed with a 2-inch ocular, yet a ¼-inch eyepiece will exhaust all definition at 360x.

Both telescopes have been ray traced to bring spherical aberration well within the Rayleigh tolerance. The f/23, without correcting the system as a complete

CASSEGRAINIAN-MAKSUTOV TELESCOPE SPECIFICATIONS

(All dimensions are in inches)

Symbol	*Characteristic*	*f/15*	*f/23*
D_c	Diameter of correcting lens	6.45	6.26
T_c	Thickness of correcting lens	0.541 ± 0.010	0.448 ± 0.010
D_m	Diameter of primary mirror	6.6	6.4
T_m	Thickness of primary mirror	1.1	1.1
D_s	Diameter of secondary spot	1.4	1.2
D_h	Diameter of hole in primary mirror	1.375	1.17
R_1	Radius of curvature of 1st lens surface	−6.583 ± 0.070	−8.040 ± 0.070
R_2	Radius of curvature of 2nd lens surface	−6.888 ± 0.070	−8.293 ± 0.070
R_3	Radius of curvature of primary mirror	−30.83 ± 0.50	−43.39 ± 0.50
R_4	Radius of curvature of secondary spot	−6.888 ± 0.070	−8.293 ± 0.070
CA	Clear aperture of correcting lens	6.0	6.0
BA	Back aperture of correcting lens	6.3	6.11
S	Separation of lens and mirror	12.867	18.541
BFL	Back focal length	17.16	23.05
	Effective focal length	90.0	140.0

unit but making each element separately, has a zonal residual of 0.030", 1/10 the Rayleigh tolerance. Residual coma is within the Rayleigh limit over a field of 1.4" diameter. In the faster f/15 system, spherical aberration is still less than one quarter Rayleigh's tolerance and the coma is negligible.

Either design may be scaled up or down and, to a certain extent, may be made of different speed by scaling apertures only. Between f/15 and f/20, the 90" design should be adapted by closing down the aperture; anything slower than f/20 should be scaled from the 140" design. With such slow systems (f/15 to f/23) the type of eyepiece chosen is not critical, and Huygens oculars can be used. I prefer the wide apparent fields of the (Abbe) orthoscopic and the Erfle eyepieces.

Tolerances. Because all surfaces in the Cassegrainian-Maksutov are spherical, one must not be misled into thinking that the figuring tolerances are loose. The surfaces must be well figured if the telescope is to give the high performance inherent in the design.

For instance, the secondary magnifies the primary image over six times; it is evident that any zone visible in a knife-edge test of the primary is intolerable. On the other hand, if the shell is figured well, the secondary itself presents no problem as it is but a small part of the large back surface and will automatically be smooth.

And in final assembly, spacing of the elements is very critical, the position of the final focus being proportional to the amplification factor squared. Thus, if the shell and mirror separation is wrong by only 1/10 inch, the focal plane will be shifted by over four inches from the design position!

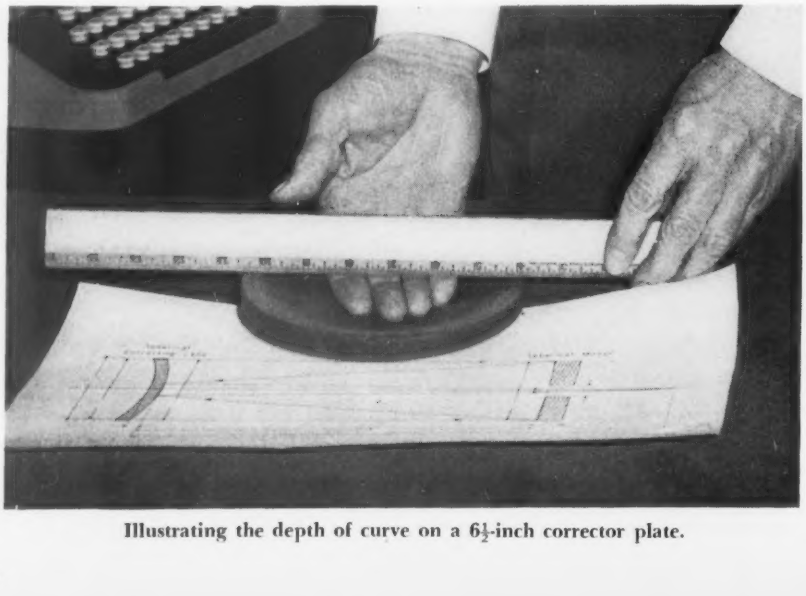
It is evident, therefore, that the concentricity of the shell and its thickness have strict tolerances. The differences in edge thickness should be reduced to less than 0.001"—otherwise one will have a built-in objective prism giving star spectra instead of Airy star disks!

As in most lens work, figured surface by surface, the tolerances of radii are very strict. The surfaces of the corrector lens, $\mathbf{R}_1$ and $\mathbf{R}_2$, may vary *together* from the design by as much as 0.07" in radius of curvature, but both in the same direction. The variation of $\mathbf{R}_1$ should equal that of $\mathbf{R}_2$ within 0.004". The primary mirror, however, need be made only within 0.5" of the specified radius of curvature.

The smoothness of all surfaces should be $\frac{1}{4}$ wave or better. If one is lucky enough to own an aluminized $\frac{1}{8}$-wave optical flat with a diameter equal to or greater than the telescope aperture, the final testing may be done by autocollimation. With the pinhole and knife-edge in the focal plane, the light traverses the system twice, giving a doubly sensitive null test of the assembly.

A highly accurate paraboloidal mirror may also be used to obtain collimated light, with the pinhole placed at the focus of this mirror. The knife-edge is set in the focal plane of the catadioptric system, where it effects the null test with ordinary sensitivity. With collimated light all tolerances can be broadened, as it is possible to remove, by figuring, residuals caused by 10 times the given departures from the nominal design (with the exception of concentricity, which must still be within 0.001").

If curves or thickness have fallen outside the tolerances, the final figuring involves slightly aspherizing the front surface of the corrector or the primary, but those without experience in such critical work can achieve the desired results by making each surface to strict tolerances. The assembled telescope will perform so well that the amateur will be unable to find any fault, and will wonder why he waited so long to construct such an ideal instrument.



Illustrating the depth of curve on a 6½-inch corrector plate.

Materials. The glass for the corrector lens, a borosilicate crown, BSC-2 (517645), was chosen for its resistance to tarnishing, low dispersion, general availability and cheapness, although any of the crown glasses would be quite suitable if the design were adapted appropriately. BSC-2 may be obtained from any of the domestic glass manufacturers, or Schott BK-7, imported by Fish-Schurman Corp., may be used. The disks should be fine-annealed grade A or B.

The minimum dimensions of the blank for the shell depend on the method of generating the working curves. If this can be accomplished with a diamond-wheel curve generator, only a minimum of glass is removed (the fine grinding and polishing stages require at most about 0.04″), and a rough blank for the f/15 design needs to be about 6½″ in diameter and 1⅓″ thick; for the f/23, 6¼″ by 1¹⁄₁₆″ will suffice.

But if the amateur must rough out and shape the lens by handwork, starting with coarse carborundum, a substantially greater amount of glass must be available to start with. To allow for roughing out, wedge control, and radius checking, the diameter ought to be 6⁹⁄₁₆″, and the thickness 1½″, for the f/15 design; these reduce to 6⁵⁄₁₆″ by 1³⁄₁₆″ for the f/23.

Blanks from surplus stock will not always meet these requirements of size, especially in the f/15. But with prices as reasonable as those given below, it will pay the amateur to figure carefully the maximum size of corrector lens he can make from the blank he receives, scaling the design slightly to fit that size. In many cases, only about a quarter of an inch in aperture will be lost.

Examples of surplus stock are found in the catalogues of Edmund Scientific Co. and A. Jaegers. The latter lists objective quality BSC-2 disks 4⅜″ in diameter by ¹¹⁄₁₆″ thick (#1590) at $7.50. Edmund has BSC-2 fine-annealed grade B slabs 4½″ square by about 28 mm. (#50,119) at $3.00; 6½″ by 28 to 29 mm. (#50,120) at $6.00. This company states that for Maksutov correctors it can supply its stock #50,140, minimum size 6½″ square by 32 mm. minimum thickness, at $7.00; an actual blank may come larger in either dimension.

The primary mirror should be made of pyrex or other low-expansion glass. In addition to the standard 4¼-6-8-10-inch diameter Corning series, pyrex blanks 5″ in diameter by 1″ thick can now be obtained from the Hayward Optical Glass Co. for about five dollars each. These would make a suitable primary for a 4½″ Maksutov corrector lens.

Aluminum is recommended as a tube material, and is now available in seamless tubing ¹⁄₁₆″ thick. For the 6-inch Cassegrainian-Maksutov, if a lathe is available, consider making both mirror and lens cells as well as the tube from a single piece of aluminum pipe, thus simplifying the machining and insuring alignment of the two elements. Local warehouses can supply such pipe, usually with a wall thickness of ½″, or more in larger sizes. Aluminum seamless tubing of 8″ outside diameter, ³⁄₃₂″ wall thickness, is available from the Metal Goods Corp.

Optical Processing. Mirror fabrication is a routine matter, but the figure smoothness should be such that no shadows are visible when knife-edge testing is done at the center of curvature.

Work on the corrector lens starts with edging, which may be omitted, however, if the blank is almost round to start with, having a variation of no more than ¹⁄₃₂″ across different diameters. If a diamond tool is not available, the disk must be mounted and edged with a steel plate and carborundum. This is the one and final such operation, since centering by re-edging is not economical on a lens with nearly concentric surfaces.

The concave surface, $\mathbf{R}_1$, is roughed in first, with periodic checks on its radius of curvature, until the curve extends to within ¼″ of the edge of the lens. The centering of this concave side may be roughly checked by measuring this ¼″ annulus to see whether or not its width varies around the disk. In this work, if no iron tool is available and you are not grinding by hand, another blank, of either plate glass or pyrex, is generated to serve as a tool. If thick enough, the

reverse side can also be used as a tool for the convex surface, R_2.

While R_1 is being brought through grinding, keep a record of the thickness changes; this will help you judge how thick to leave the lens while generating R_2 in order to end up close to the nominal thickness after fine grinding. Be sure to add 0.02" to the thickness allowed, as this may be needed to eliminate any wedge effect, which will be done during fine operations on R_2. The amount of wedge may be determined with a 1" micrometer blocked to measure at a single diameter on the lens.

Before polishing R_1, bring R_2 through the fine-grinding stage, checking its radius of curvature on its concave tool with a depth micrometer. Then spray R_2 with Krylon or shellac to protect it while finishing R_1, which should be brought to a $\frac{1}{4}$-wave sphere by repeated use of the knife-edge test.

R_2 may now be polished, and figured by testing *through* R_1 as outlined by Franklin B. Wright in his article on pages 574 to 580 in *Amateur Telescope Making—Book Three.* If a smooth $\frac{1}{4}$-wave sphere is obtained, the central $1\frac{1}{4}$" will be well within tolerance for use as the secondary. When the lens is sent out for spot aluminizing, it would be well to include a round sheet-metal mask with a central hole of the desired spot diameter. If the aluminizing concern has to make up such a jig, it will cause delay and add to the expense.

In addition to the references already given, the reader may wish to consult Maksutov's original paper in the *Journal* of the Optical Society of America, *34*, 5, May, 1944, beginning on page 270; articles in *ATM-3* beginning on pages 1, 163, and 574; and A. Bouwers' book, *Achievements in Optics*, 1950, Elsevier Book Co., Inc., 215 Fourth Ave., New York, N. Y.

The addresses of suppliers mentioned above are: Corning Glass Co., Corning, N. Y.; Edmund Scientific Co., Barrington, N. J.; Fish-Schurman Corp., 70 Portman Rd., New Rochelle, N. Y.; Hayward Optical Glass Co., 217 Magnolia Ave., Whittier, Calif.; A. Jaegers, 691S Merrick Rd., Lynbrook, N. Y.; Metal Goods Corp., 8800 Page Blvd., St. Louis, Mo.

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NOTE: Interest in telescopes of the Maksutov type for amateur use is increasing rapidly. Alan M. Mackintosh's Maksutov club has about 200 correspondents registered since the first announcement in the October issue (see also page 92, December issue).

Mr. Gregory is a mechanical engineer working on optical system development at the Perkin-Elmer Corp., Norwalk, Conn. He has provided the above details of his designs for amateur use only; the Perkin-Elmer Corp. retains all commercial rights. R. E. C.


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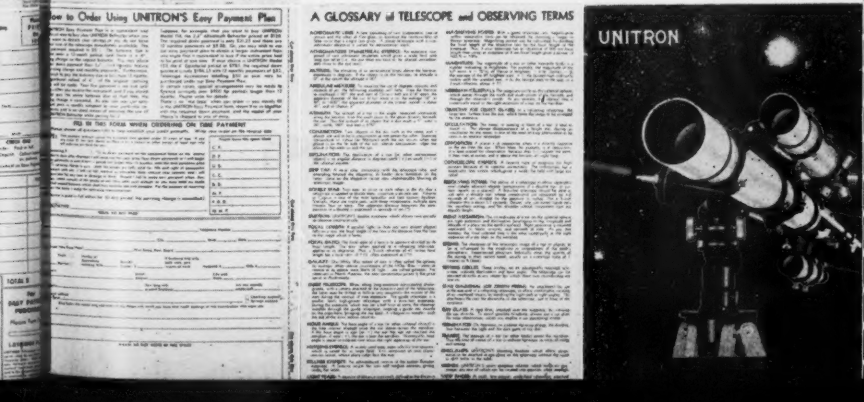

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A Bright Comet Due in the Spring Sky

COMET 1956h, discovered by S. Arend and M. Roland of Uccle Observatory, Belgium, on photographs taken last November 8th, may become one of the most striking naked-eye comets in recent years. In early March it will be observable low in the southwestern sky just after sunset. Most of April it will be too close to the sun in the sky to be seen, but by May will reappear in the northwest, probably fairly conspicuous during the early evening.

When first found, Comet Arend-Roland was of the 10th magnitude and diffuse, located just east of Alpha Trianguli, and moving southwestward. Apparently nearly two weeks elapsed before the cometary image was recognized on the Uccle plates, since the first general announcement of the new discovery was made on November 19th. (The earliest reports erroneously gave the date of discovery as November 6th instead of the 8th.)

An even earlier observation of Comet 1956h was subsequently reported from Japan. At the Tokyo Observatory's Konko branch station, S. Kaho had been photographing that part of the sky for variable stars—the comet was found on a plate exposed on November 7th, about 34 hours before the first Belgian photograph.

During December and January, the comet continued its southwestward motion through Pisces. As Comet Arend-Roland moved nearer to the sun, it brightened slowly, while observers at Uccle noted night-to-night fluctuations in brightness over a two-magnitude range. Position measurements were being made at observatories in Austria, Belgium, China, Czechoslovakia, Denmark, Finland, Germany, Great Britain, Greece, Spain, in the United States, and probably elsewhere. From these observations the orbit of Comet Arend-Roland was calculated by several astronomers independently, with closely accordant results.

G. Merton, of Oxford University Observatory, England, found that the comet will arrive at the perihelion point of its orbit on April 8, 1957. On that date, its distance from the sun will be only 29.7 million miles, less than one third the radius of the earth's orbit. Although forecasts of comet brightnesses are notoriously uncertain, with many cases of widely heralded "great comets" that failed to become conspicuous, a striking development for this object appears likely.

On the assumption that it will follow a normal pattern of development, Dr. Merton predicts that the comet may reach magnitude −1 by mid-April, but its proximity to the sun may make it unobservable then. After perihelion passage, it will move northward very rapidly, across Pisces into Triangulum again. On April 22nd, when its magnitude may be approximately +1, the new comet will be

COMET AREND-ROLAND (1956 h)

1957	α 1950.0	δ 1950.0	Δ	r	Mag.* m_1	Mag.* m_2	From the Sun	
Feb. 11	$0^h18^m.2$	$-2°13'$	1.939	1.366	$7^m.9$	$6^m.5$	$+2^h.7$	$+12°.2$
21	21.6	4 11	1.899	1.180	7.2	5.5	+2.1	+ 6.8
Mar. 3	26.0	6 13	1.818	0.983	6.3	4.2	+1.5	+ 0.7
13	30.9	8 30	1.683	0.776	5.1	2.5	+1.0	− 5.5
23	35.6	11 8	1.475	0.561	3.4	0.1	+0.5	−12.0
Apr. 2	39.6	13 5	1.156	0.368	1.1	−3.2	−0.1	−17.9
12	0 52.7	− 3 34	0.773	0.338	−0.2	−4.6	−0.5	−12.2
17	1 19.1	+12 15	0.598	0.412	0.1	−3.9	−0.3	+ 1.9
22	2 1.4	32 35	0.572	0.511	1.0	−2.6	0.0	+20.5
27	2 59.7	48 41	0.643	0.618	2.0	−1.1	+0.7	+35.0
May 2	4 5.9	57 45	0.767	0.726	3.1	0.3	+1.5	+42.5
7	5 8.7	61 51	0.913	0.832	4.1	1.6	+2.2	+45.1
12	6 5.5	63 19	1.066	0.936	4.9	2.7	+2.8	+45.2
17	6 41.0	63 33	1.219	1.036	5.7	3.7	+3.1	+44.3
22	7 12.3	63 15	1.371	1.135	6.3	4.5	+3.3	+42.9
June 1	7 57.9	62 7	1.661	1.324	7.4	5.9	+3.4	+40.1
11	8 30.4	60 54	1.930	1.504	8.3	7.1	+3.7	+37.8
21	8 56.4	59 49	2.179	1.676	9.0	8.0	+3.0	+36.4
July 1	9 18.6	+58 54	2.405	1.843	9.7	8.9	+2.6	+35.7

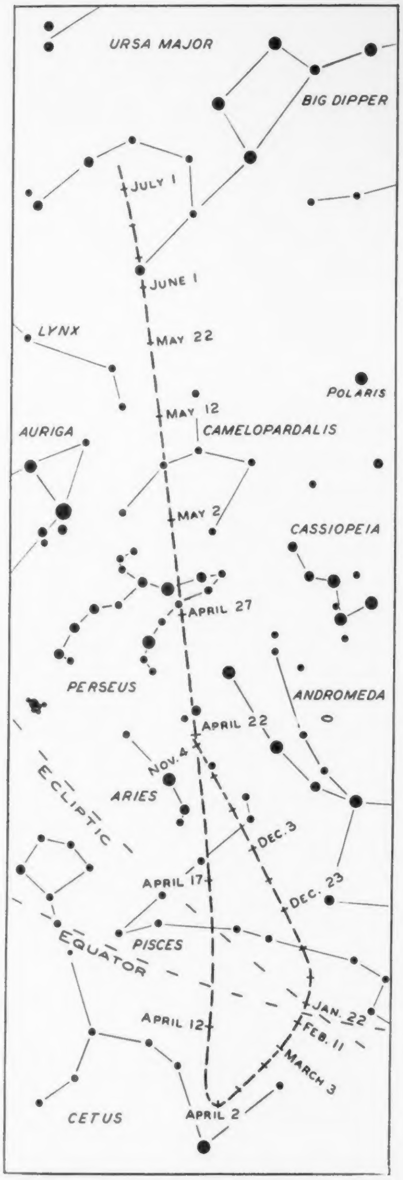
* $m_1 = 5.1 + 5 \log \Delta + 10 \log r$ $m_2 = 3.0 + 5 \log \Delta + 15 \log r$

In this ephemeris of Comet 1956h computed by I. Hasegawa, Yamamoto Observatory, Japan, successive columns list the date; the right ascension and declination; the comet's distance from the earth and from the sun, expressed in astronomical units; the magnitude of the comet as calculated from the two assumed formulas given at the bottom; and the comet's sky co-ordinates relative to the sun. Reproduced from Circular 1580 of the International Astronomical Union, distributed from Copenhagen Observatory.

only a few degrees from the spot in the sky that it occupied at the time of discovery $5\frac{1}{2}$ months earlier.

Fading slowly as it crosses Perseus, the comet will enter Camelopardalis at the beginning of May. Then it is expected to be about 3rd magnitude and well placed for viewing in the northwestern sky at the end of evening twilight. The total length of its naked-eye visibility may reach three months.

Reports and photographs of the comet by amateurs may be sent to *Sky and Telescope* for possible publication. Details of the comet's physical appearance and brightness should be accompanied by data on the times of observations, instruments used, and condition of the observer's sky.



The path of Comet Arend-Roland from early November, 1956, until July 1, 1957.

Comet Arend-Roland, photographed at Yerkes Observatory by G. Van Biesbroeck with the 24-inch reflector. Above, on December 27th, the comet was magnitude 11.1 and had a tail eight minutes long. The lower picture, taken January 24th, shows the comet, magnitude 10.0, 10-minute tail. Yerkes Observatory photos.

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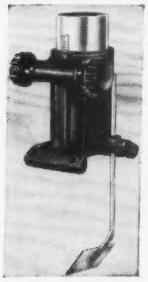

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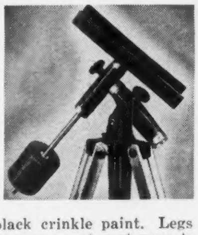

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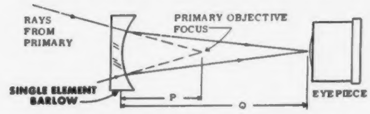

WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to short focal length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power. The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q!

Beautiful chrome mount. We now have our Barlow lens mounted in chrome-plated brass tubing with special spacer rings that enable you to vary easily the power by sliding split rings out one end and placing them in other end. Comes to you ready to use. Just slide our mounted lens into your 1¼" I.D. tubing then slide your 1¼" O.D. eyepieces into our chrome-plated tubing. Two pieces provided, one for regular focal length eyepieces and one for short focal length ones.

Remember, in addition to doubling and tripling your power, a Barlow lens increases your eye relief and makes using a short focal length eyepiece easier.

Don't fail to try one of these. Many people do not realize the many advantages of a Barlow and the much greater use they can get from their telescopes. Our Barlow has a focal length of −1 5/16". We have received many complimentary letters about this lens. So sure are we that you will like it that we sell it under a 30-day guarantee of satisfaction or your full purchase price returned—no questions asked. You can't lose, so order today.

Stock #30,200-Y Mounted Barlow lens $8.00 ppd.

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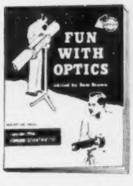

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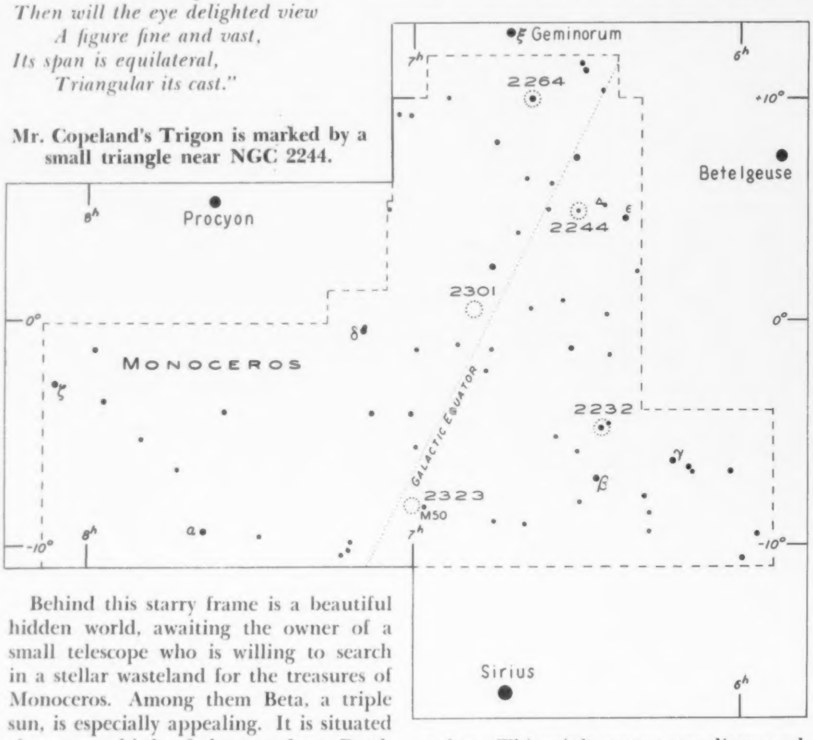
The Buried Treasure of Monoceros

ORION, first among the winter constellations, has an obscure neighbor, unknown to the ancients and seldom observed by amateurs today. Following the "hunter of the beast" is Monoceros, the Unicorn, a dim area of the Milky Way.

The name of this neglected constellation is a Greek word meaning *one horn.* A pattern can hardly be drawn among its stars, and as Monoceros has no star brighter than 4th magnitude, it might well be described by Tennyson's line, "Swallowed in vastness, lost in silence, drowned in the deeps of a meaningless past."

To find Monoceros is easy if one looks for the great triangle formed by three 1st-magnitude stars, Procyon, Betelgeuse, and Sirius. This bounds the most interesting part of the constellation. An old stanza, saved for posterity by Admiral Smyth, praises this resplendent delta:

"Let Procyon join with Betelgeuze,
And pass a line afar,
To reach the point where Sirius glows—
The most conspicuous star;
Then will the eye delighted view
A figure fine and vast,
Its span is equilateral,
Triangular its cast."



Mr. Copeland's Trigon is marked by a small triangle near NGC 2244.

Behind this starry frame is a beautiful hidden world, awaiting the owner of a small telescope who is willing to search in a stellar wasteland for the treasures of Monoceros. Among them Beta, a triple sun, is especially appealing. It is situated about two thirds of the way from Betelgeuse to Sirius. North of it, but relatively close, is the cluster NGC 2232, which might be called the Double Wedge.

Slightly north and east of the center of the great triangle is NGC 2301, the Golden Worm, a cluster of 60 stars that forms a curving group topped with a flying wedge of suns.

About two thirds of the way from Procyon to Sirius is another cluster, M50. According to Harlow Shapley it has 100 stars, but it is less striking than this number implies; its appearance suggests that we call it the Coil.

The fairest specimens of celestial jewelry in this region are the Christmas Tree, NGC 2264, and the Harp, NGC 2244. The first is a cluster of 20 gems not far from Xi Geminorum and well above the top line of our equilateral triangle. It has a bright star at the bottom of the tree and a double at the top, but much of the time the tree is not seen upright.

The Harp is a rather small cluster of 16 suns, most of them bright, near Epsilon Monocerotis (which itself is an easy double star). This cluster is the heart of a remarkable nebula known as the Rosette, more than 3,000 light-years from the earth. Although the nebulosity cannot be seen through ordinary telescopes, the Harp is compensation.

A little west and north of NGC 2244 nestles a beautiful, very small delta of stars, a delightful object I call the Trigon, which has seemingly been overlooked by almost all observers. Some of us will take special possession of this miniature marvel of three relatively bright stars, close together. This triple system was discovered by Wilhelm Struve over a century ago, and is number 939 in his catalogue; it consists of an 8th-magnitude star and two others of the 9th magnitude within about 40 seconds of arc.

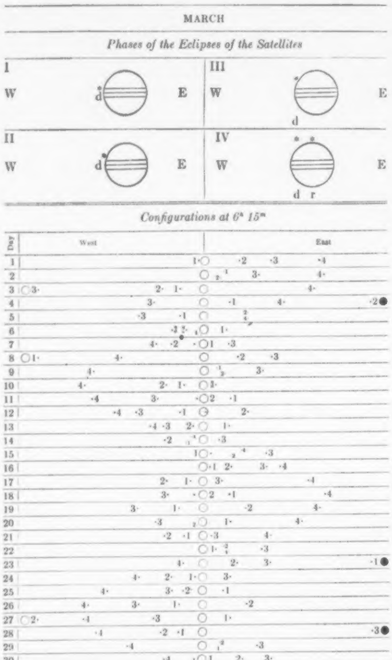
When explored with a telescope, the entire constellation of Monoceros is radiant with a multitude of suns and with other clusters. Although celestial glories such as these were not especially made for Man, they will enrich leisure hours.

LELAND S. COPELAND
1124 State St.
Santa Barbara, Calif.

JUPITER'S SATELLITES

The configurations of Jupiter's four bright moons are shown below, as seen in an astronomical or inverting telescope, with north at the bottom and east at the right. In the upper part, *d* is the point of disappearance of the satellite in Jupiter's shadow; *r* is the point of reappearance.

In the lower section, the moons have the positions shown for the Universal time given. The motion of each satellite is from the dot toward the number designating it. Transits over Jupiter's disk are shown by open circles at the left, eclipses and occultations by black disks at the right. The chart is from the *American Ephemeris and Nautical Almanac*.



PREDICTIONS OF BRIGHT MINOR PLANET POSITIONS

Thetis, 17, 9.7. March 13, 13:18.1 +0-38; 23, 13:11.9 +1-50. April 2, 13:03.9 +3-04; 12, 12:55.2 +4-10; 22, 12:47.0 +5-00. May 2, 12:40.6 +5-29.

Flora, 8, 9.8. April 22, 16:09.3 −12-53. May 2, 16:01.5 −12-24; 12, 15:51.8 −11-56; 22, 15:41.1 −11-32. June 1, 15:30.7 −11-16; 11, 15:21.6 −11-10.

After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0^h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

MINIMA OF ALGOL

March 3, 16:56; 6, 13:45; 9, 10:34; 12, 7:23; 15, 4:13; 18, 1:02; 20, 21:51; 23, 18:40; 26, 15:30; 29, 12:19. April 1, 9:08; 4, 5:57.

These minima predictions for Algol are based on the formula in the 1953 *International Supplement* of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of least brightness.

UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown.

OCCULTATION PREDICTIONS

March 9-10 **Chi[1] Orionis** 4.6, 5:51.8 +20-16.2, 9. Im: **F** 5:32.2 ... ... 27; **H** 4:47.6 −2.4 +1.4 51.

March 16-17 **Chi Virginis** 4.8, 12:37.0 −7-45.6, 16. Em: **E** 3:33.1 0.0 −2.0 349; **F** 3:38.2 −0.7 −0.2 305.

March 19-20 **Kappa Librae** 5.0, 15:39.5 −19-32.5, 19. Em: **F** 11:06.5 −2.2 −2.1 320; **H** 10:19.2 −1.4 −0.7 312; **I** 10:04.4 ... ... 345.

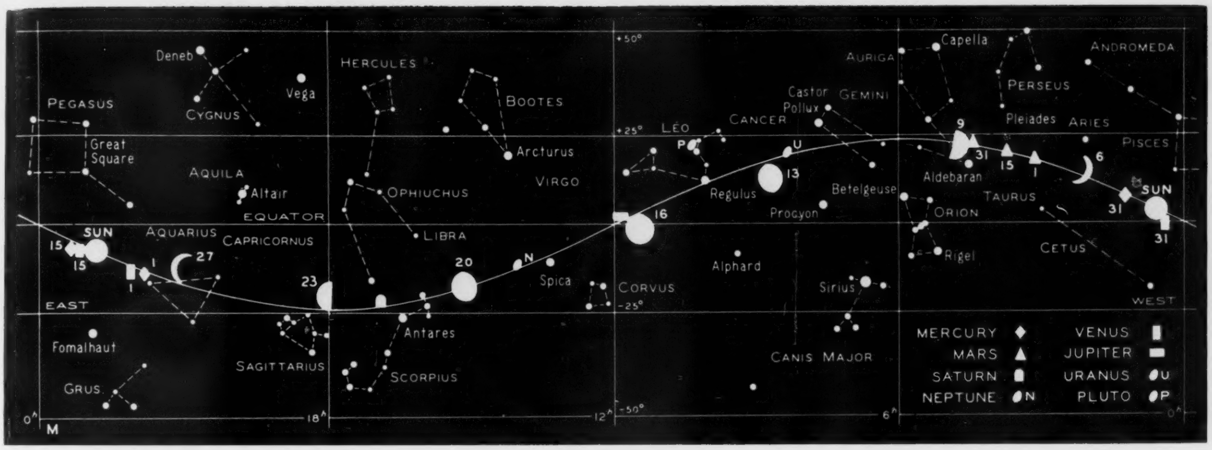
March 22-23 **21 Sagittarii** 5.0, 18:22.8 −20-34.0, 22. Em: **E** 11:07.9 −2.1 +0.9 258; **F** 10:39.9 −2.3 +2.0 237.

For stations in the United States and Canada, usually for stars of magnitude 5.0 or brighter, data from the *American Ephemeris* and the *British Nautical Almanac* are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, UT, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**LO — LoS**), and multiply **b** by the difference in latitude (**L — LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

A	+72°.5,	+42°.5	**E**	+91°.0,	+40°.0
B	+73°.6,	+45°.5	**F**	+98°.0,	+31°.0
C	+77°.1,	+38°.9	**G**	Discontinued	
D	+79°.4,	+43°.7	**H**	+120°.0,	+36°.0
			I	+123°.1,	+49°.5



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other dates shown.

Mercury will not be visible this month, due to its proximity to the sun. Superior conjunction occurs on March 20th, Mercury then entering the evening sky.

Venus also cannot be viewed, as it is in the morning sky very close to the sun.

Earth arrives at heliocentric longitude 180° on March 20th at 21:17 UT. Spring commences in the Northern Hemisphere and autumn in the Southern, with days and nights approximately equal everywhere.

Mars continues its rapid eastward motion, now setting shortly before midnight. At midmonth Mars is in western Taurus, and has an apparent magnitude of +1.4.

Jupiter, in western Virgo, is visible all night, as it reaches opposition to the sun on March 17th. On that date it is 413 million miles from the earth, shining at magnitude −2.0, its disk having an equatorial diameter of 44″.2. Jupiter is in retrograde motion throughout the month; on the 23rd it passes less than 1° north of the 3.8-magnitude star Beta Virginis.

Saturn rises in the southeast at midnight about March 22nd, after passing western quadrature with the sun on the 4th. The ringed planet is now in Ophiuchus, about 8° northeast of Antares and slightly brighter than this red star. Retrograde or westward motion begins on the 24th, preceding opposition on June 1st.

Uranus may be observed through the night, as it sets only shortly before dawn. This 6th-magnitude object, the faintest planet visible to the unaided eye, is in retrograde motion about 4° west of the Beehive cluster in Cancer.

Neptune is also in slow retrograde motion, about 2° west of Kappa Virginis. It rises about midevening and may be seen with the aid of binoculars or a small telescope.

E. O.

SUNSPOT NUMBERS

December 1, 183, 163; **2,** 147, 145; **3,** 155, 169; **4,** 175, 194; **5,** 155, 190; **6,** 146, 175; **7,** 149, 173; **8,** 148, 157; **9,** 164, 165; **10,** 147, 204; **11,** 153, 229; **12,** 185, 200; **13,** 171, 184; **14,** 211, 218; **15,** 152, 198; **16,** 161, 186; **17,** 163, 174; **18,** 100, 156; **19,** 94, 151; **20,** 112, 130; **21,** 134, 173; **22,** 151, 193; **23,** 160, 215; **24,** 185, 219; **25,** 195, 229; **26,** 199, 216; **27,** 186, 215; **28,** 190, 202; **29,** 160, 185; **30,** 153, 168; **31,** 170, 174. Means for December: 159.8 American, 185.5 Zurich.

Above are given the date, the American number, then the Zurich number. These are observed mean relative sunspot numbers, the American computed by Dr. Sarah J. Hill from AAVSO Solar Division observations, the Zurich numbers from Zurich Observatory and its stations in Locarno and Arosa.

The previously unreported American sunspot numbers for November, 1956, are:

November 1, 153; **2,** 176; **3,** 169; **4,** 183; **5,** 209; **6,** 254; **7,** 287; **8,** 265; **9,** 207; **10,** 225; **11,** 224; **12,** 178; **13,** 180; **14,** 177; **15,** 221; **16,** 170; **17,** 161; **18,** 150; **19,** 145; **20,** 143; **21,** 121; **22,** 131; **23,** 95; **24,** 104; **25,** 120; **26,** 126; **27,** 126; **28,** 155; **29,** 180; **30,** 157. Mean for November: 173.1 American.

MOON PHASES AND DISTANCE

New moon	March	1, 16:12
First quarter	March	9, 11:50
Full moon	March	16, 2:22
Last quarter	March	23, 5:04
New moon	March	31, 9:19
First quarter	April	7, 20:32

	March	Distance	Diameter
Perigee	14, 22^h	223,100 mi.	33′ 17″
Apogee	27, 4^h	252,100 mi.	29′ 27″
	April		
Perigee	12, 1^h	226,200 mi.	32′ 51″

VARIABLE STAR MAXIMA

March 2, T Centauri, 133**633**, 6.1; 2, X Monocerotis, 065**208**, 7.6; 2, Z Ursae Majoris, 115158, 6.6; 3, T Herculis, 180531, 8.0; 5, RR Scorpii, 165**030**, 6.0; 5, T Normae, 153**654**, 7.4; 18, R Cassiopeiae, 235350, 6.5; 19, T Ursae Majoris, 123160, 7.9; 20, V Coronae Borealis, 154639, 7.4; 27, RS Herculis, 171723, 8.0.

April 3, R Draconis, 163266, 7.6; 3, R Indi, 2228**57**, 8.0; 4, V Monocerotis, 061**702**, 7.1; 7, R Virginis, 123307, 6.9; 9, R Cancri, 081112, 6.8; 10, R Geminorum, 070122a, 7.1.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

SOUTHERN STARS

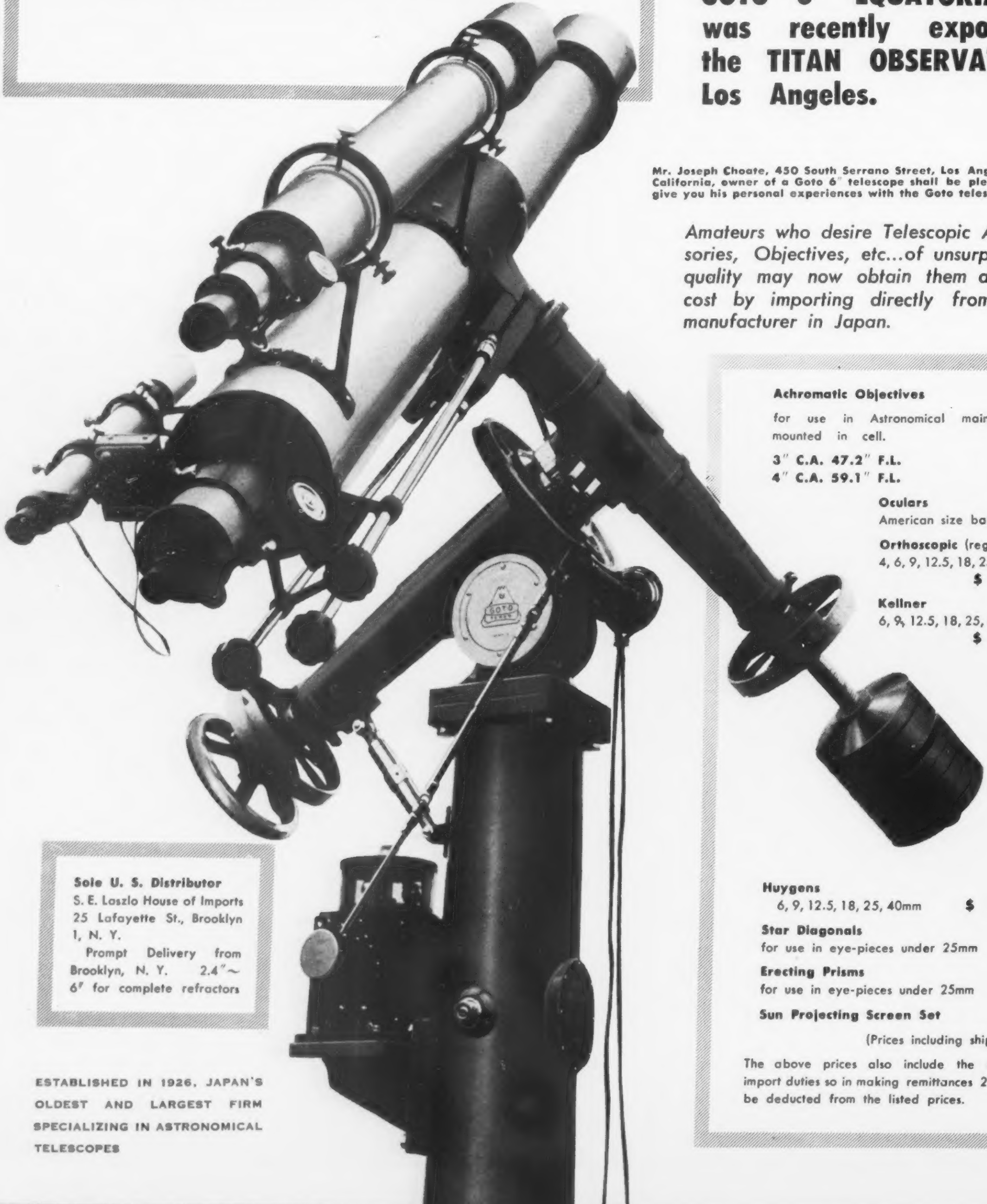
The sky as seen from latitudes 20° to 40° south, at 11 p.m. and 10 p.m., local time, on the 7th and 23rd of May, respectively; also, at 9 p.m. and 8 p.m. on June 7th and 23rd. For other dates, add or subtract ½ hour per week.

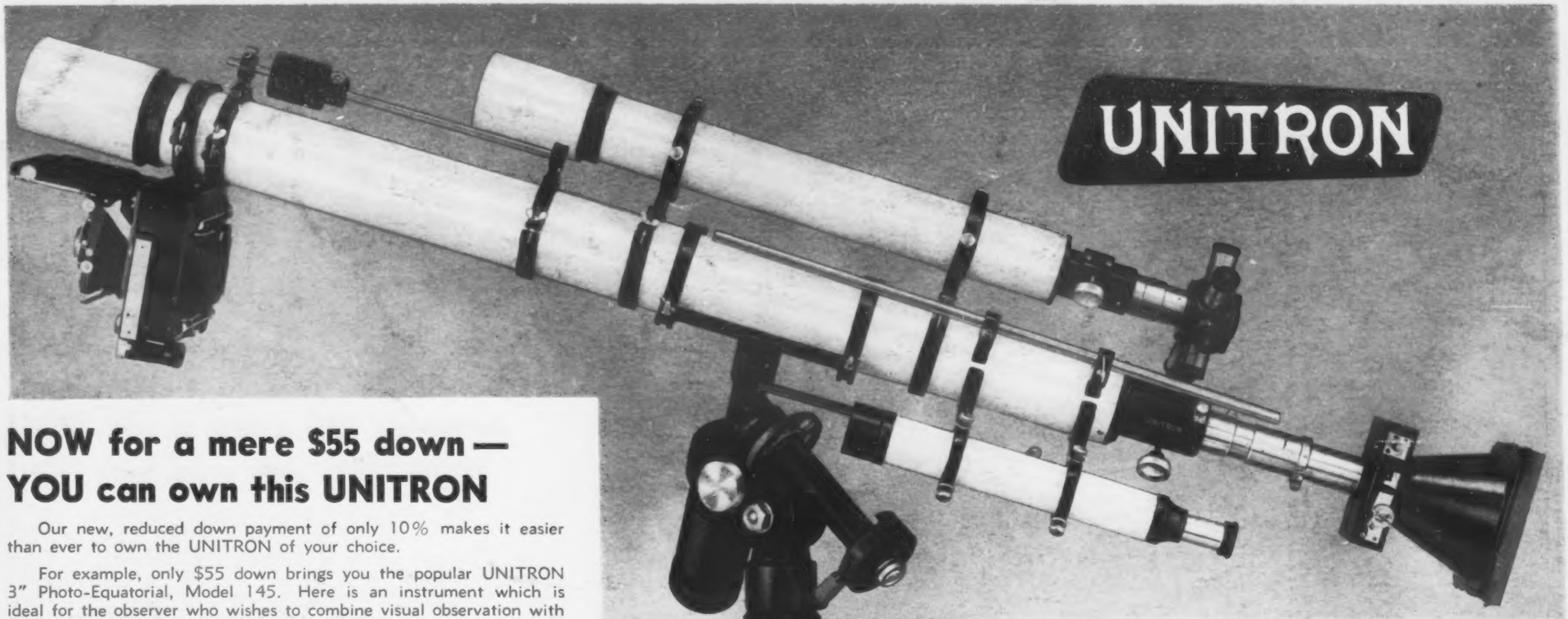
Four planetary nebulae on this chart are now well placed for telescopic observation: **NGC 3242 in Hydra, magnitude 9.0, size 40″ by 35″; NGC 3918, Centaurus, 8.4, 13″; NGC 6210, Hercules, 9.7, 20″ by 13″; NGC 6572, Ophiuchus, 9.6, 16″ by 13″. All appear bluish green.**

STARS FOR MARCH

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of March, respectively; also, at 7 p.m. on April 7th. For other dates, add or subtract $\frac{1}{2}$ hour per week.

Jupiter dominates the eastern part of the sky at chart time. It is easy to identify the giant planet in western Virgo, a region lacking bright stars. Jupiter, in opposition to the sun on March 17th, is most suitable for evening observing with small telescopes this month.





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See pages 242 and 243.

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